The Impacts of Deregulation on the Jordanian Banking Sector 1993-2006: An Empirical Analysis Using Frontier Approaches

by

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Abstract

During the period 1993-2006 the Central Bank of Jordan (CBJ) undertook a series of measures to deregulate its banking system. Key procedures included the removal of restrictions on interest rates, expansion of scope of banks' products and services, lifting of restrictions on foreign exchange transactions and the reduction of barriers to entry of foreign investors and foreign banks. The main aims of deregulation were to promote a diversified, efficient and competitive banking system in order to improve resource allocation, financial viability and operational flexibility.

A data set from the CBJ comprising all the Jordanian banks, covering the time period 1993-2006 was used to examine whether the efficiency of Jordanian banks has improved (or changed) over this time period. To this end, a parametric approach, stochastic frontier analysis, (SFA) and a nonparametric approach, data envelopment analysis, (DEA) was used to measure the efficiency scores of Jordanian banks over the period 1993-2006.

The main conclusion for this thesis suggests that the level of efficiency scores for the Jordanian banks worsened over the period 1993-2006. The average cost efficiency fell from around 86% in 1993 to around 79% in 2006. Regarding profit efficiency, average efficiency scores fell from around 82% in 1993 to approximately a low of 59% in 2006. Linking the deregulation process put in place by the CBJ with the efficiency scores over 1993-2006, the efficiency scores improved in the period characterised by deregulation of the interest rates (i.e. 1993-1996) by about 1% (for SFA cost efficiency) and about 2% (for SFA profit efficiency). However, the deregulation put in place over 1997-2001 had negative impacts on Jordanian banks' efficiency scores. The SFA cost efficiency scores are reduced on average by 8%, where the SFA profit efficiency scores are reduced by about 10%. This period is characterised by deregulation, which increased the scope and provision of bank products and services. This stage led to many Jordanian banks' becoming more risky, which in turn decreased the efficiency of Jordanian banks. However, after the year 2003, there was little improvement in the Jordanian banks' efficiency (as a result of entry of many foreign banks into the Jordanian banking market and the CBJ worked from the year 2001 to strengthen its regulation on corporate governance and the issues relating to risk management. Additionally, the results indicated that: profit inefficiencies appear to be greater than cost inefficiencies; foreign banks are more cost efficient than domestic banks; Islamic banks are found to be the least cost efficient and; large banks seem to be relatively more cost efficient.

The implication for government policy is the conventional wisdom that deregulation always improves efficiency may be incorrect. Industry conditions prior to deregulation and the existence of adequate prudential regulation and supervision procedures from the regulatory authority are also crucial for the success of such deregulation measures.

Keywords: Cost efficiency, Profit efficiency, Stochastic frontier analysis, Data envelopment analysis, Jordanian banks, Deregulation.

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Acronyms

AE	Allocative Efficiency
APE	Alternative Profit Efficiency
CBJ	Central Bank of Jordan
CD	Certificates of Deposits
CE	Cost Efficiency
CEO	Chief Executive Officer
CIR	Cost Income Ratio
COLS	Corrected Ordinary Least Square
CRS	Constant Returns to Scale
DEA	Data Envelopment Analysis
DFA	Distribution Free Approach
DMU	Decision Making Units
EE	Economic Efficiency
ES	Economies of Scope
FDH	Free Disposal Hull
GDP	Gross Domestic Product
HI	Herfindahl Index
IMF	International Monetary Fund
JOD	Jordanian Dinar
LR	Log Likelihood Ratio
LRT	Log Likelihood Ratio Test
Max.	Maximum Value
MC	Marginal Cost
Min.	Minimum Value
ML	Maximum Likelihood
MOLS	Modified Ordinary Least Square
MR	Marginal Revenue
NCE	New Cost Efficiency
NP	Net Profits
NPE	New Profit Efficiency
NPLs	Non Performing Loans
OLS	Ordinary Least Squares
PE	Profit Efficiency
PLCs	Public Listed Companies
RE	Revenue Efficiency
ROA	Return on Assets
ROE	Return on Equity
S.D.	Standard Deviation
SE	Scale Efficiency
SFA	Stochastic Frontier Analysis.
SPE	Standard Profit Efficiency
TC	Total Costs
TE	Technical Efficiency
TFA	Thick Frontier Approach
TR	Total Revenue
VRS	Variable Returns to Scale
WB	World Bank

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Chapter 1 Introduction

1.1 Background

Developing countries have historically been more controlling of the activities of their banks than industrialised countries (Gruben and McComb, 1997). However, the banking industries in many developing countries have been experiencing low levels of efficiency and subsequently poor performance, mainly due to heavy intervention by government (Barth et al., 2001, 2004; Pasiouras et al., 2006, 2007). In order to address this inefficiency and poor performance, many of these countries introduced a large liberalisation of the banking system in the early 1980s (Kumbhakar and Sarkar, 2003). An example of a banking system that has been heavily subjected to government intervention and restrictions imposed by regulatory authorities is the banking system of Jordan. Before the 1990s, the Jordanian banking industry served as an agent of the government, channelling investment funds to selected sectors under the country's economic development policy, while imposing many requirements and restrictions on banks activities. For example, the Central Bank of Jordan (CBJ): determined lending limits for banks; set a ceiling on interest rates for loans and deposits; restricted entry to the Jordanian banking market; and imposed a high reserve requirement ratio on banks and tight restrictions on foreign exchange transactions.

In 1989, the Jordanian economy faced a major crisis when the Jordanian Dinar (JOD) suffered a major devaluation (i.e. the JOD lost 51% of its value against the US Dollar), total government debt reached 197% of gross domestic product (GDP), foreign currency reserves declined sharply, the inflation rate reached 25.6% and the budget deficit, excluding grants, reached 24% of GDP (Isik et al., 2004; Alissa, 2007). This crisis negatively affected the banking sector in Jordan and led to many problems such as an increase in the ratio of non-performing loans, which subsequently led to serious consequences for the banking industry. Petra Bank, one of the largest banks in Jordan, collapsed in August 1989 and the government had to move quickly to save its banking system. As a result, since 1989 Jordan has been implementing, with the aid of the International Monetary Fund (IMF) and the World Bank (WB), a strong stabilisation and structural reform programme. The liberalisation of the banking industry in Jordan was part of the programme and aimed to improve the structure and efficiency of Jordanian banks (Crane et al., 2003). In the early 1990s and onward, the CBJ undertook a series of measures to liberalise its financial system. Key procedures included a removal of restrictions on interest rates, a reduction of lending to government, an expansion of product deregulation, removal of restrictions on foreign exchange transactions and reduction of barriers to entry of foreign banks into the Jordanian market. As in other developing counties, the main aims of the CBJ in this liberalisation programme were to promote a diversified, efficient and competitive financial system, through measures such as improving resource allocation and financial viability and operational flexibility (Crane et al., 2003; Isik et al., 2004). The government and the CBJ hope that productivity, profitability, lower intermediation costs and enhanced customer service would be achieved by the banking sector as a direct result of this liberalisation (Toukan, 2002). The emphasis on the liberalisation of the banking system in Jordan is due to the fact that in Jordan, as in other developing countries, most of the intermediation between savers and borrowers is conducted by banks (Isik et al., 2004). Therefore, it is important to examine whether the efficiency of Jordanian banks has actually improved after the implementation of the financial liberalisation programme.

1.2 Objectives and Motives of Study

The primary aims of this research. First, to measure cost and profit efficiency of the Jordanian banks during 1993-2006, using frontier approaches (i.e. parametric and nonparametric). Second, to assess the impact of the financial liberalisation which took place in Jordan in the early 1990s on the efficiency level of the Jordanian banking sector. Third, to reveal the main determinants of Jordanian banks' efficiency by examining bank-specific factors (i.e. level of risks, quality of loans, ownership structure, size of bank, specialisation, corporate control and age of banks) and market conditions (i.e. concentration, regulations) to see their impact on the level of banks' efficiency.

Despite the vast literature on efficiency in the United States and European banking industry and the rising empirical research in the context of developing countries (for example, see Berger and Humphrey, 1997; Goddard et al., 2001), very few studies have been conducted on the efficiency of the banking industry in Jordan. Two studies tested the efficiency level of Jordanian banks (i.e. Al-Jarrah, 2002; Isik et al., 2004), but It should be noted that these two studies do not take into account foreign banks operating in Jordan. The exclusion of the foreign banks from the data may have an influence on the estimation of the efficient frontier for Jordanian banks. In addition, one study used a parametric approach and the other a nonparametric. Therefore this current research is important for several reasons.

First, this study will be the first to (i) examine the impact of deregulation on the efficiency of Jordanian banks, (ii) to study the efficiency of foreign banks operating in Jordan and (iii) to use parametric and nonparametric approaches to measure cost and profit efficiency. Furthermore, this study uses a longer period (1993-2006) that covers the pre- and post-deregulation process. This period allows one to see the impact of deregulation on the efficiency level of Jordanian banks.

Second, by investigating efficiency levels in the Jordanian banking industry, an area on which there is limited empirical evidence, this study will extend and complement the existing international banking efficiency literature, which is currently significantly skewed towards developed countries.

Third, the liberalisation programme adopted by Jordan is aimed at achieving more competition and efficiency in the banking sector. Therefore this research may help policy makers to assess to what extent their policies have been successful in achieving their goals.

Fourth, recently, the CBJ has been encouraging banks to become larger through mergers and acquisitions by means of various incentives (for example, decreasing the reserve requirements ratio). In this context, it is important to determine whether or not there is a link between bank size and cost and profit efficiency levels.

Fifth, one of the main objectives of the CBJ is to ensure the safety and soundness of the banking system. This study may therefore help the CBJ in its efforts to improve the overall performance of the banking sector and identify the causes of inefficiencies.

Six, it provides a comprehensive overview of the Jordanian banking sector over the period 1993-2006. Finally, the study might also highlight some positive determinants of efficiency that could benefit bank owners and managers in improving the level of efficiency in their organisations.

This research therefore seeks to answer the following questions:

1. Are Jordanian banks inefficient in terms of incurring more costs and generating fewer profits?

2. Has the efficiency of banks in Jordan improved after the implementation of liberalisation?

3. Does the level of equity and non-performing loans within banks have any impact on their costs and profits (i.e. increase or decrease costs (profits))?

4. Is the efficiency of foreign banks lower (higher) than that of domestic banks?

5. Are the specialised banks (Islamic, investment banks) more (less) efficient than commercial banks?

6. Are big banks (i.e. in terms of asset size) more (less) efficient than small banks?

7. Are old banks (i.e. in terms of date of foundation) more (less) efficient than new banks?

8. Is the efficiency of banks that designate the same person to occupy the role of chairman of the board and chief executive officer lower (higher) than that of banks that separate the positions?

9. Is efficiency enhanced in more a competitive market structure?

1.3 Research Methods

To answer the above questions, the present study uses frontier approaches to measure the efficiency of Jordanian banks. As outlined in Chapter 2, various parametric and nonparametric approaches have been used in the empirical literature to measure of the bank efficiency. Following the studies reviewed in Chapter 3, Chapter 5 uses a parametric stochastic frontier approach (SFA) and nonparametric data envelopment analysis (DEA) to calculate the efficiency of banks in Jordan. As this study aims to investigate the impact of liberalisation on the efficiency levels of Jordanian banks, as well as factors that may explain variations in the efficiency of banks over time, it employs the so-called one-stage analysis developed by Battese and Coelli (1995). In one-stage analysis, a set of control and environmental variables accounting for bank-specific factors (e.g. bank size, ownership structure, level of risk) and market condition (e.g. concentration, regulations) are included directly in the model to estimate the efficiency level of Jordanian banks. The failure to include bank-specific variables and market condition in the first stage leads to a biased estimation of the parameters of the cost frontier and to biased predictors of cost efficiency (Coelli et al., 1999). Moreover, this study uses contemporary literatures by estimating different models and statistical testing (i.e. log ratio test) to choose the best model that will be used to estimate efficiency scores for Jordanian banks. The issues of one-stage analysis and the estimation of different models will be discussed in detail in Chapter 5. To check the robustness of the results derived from SFA and DEA, this study follows the recommendation of Bauer et al. (1998) to test the consistency between efficiency scores derived from SFA and DEA.

1.4 Data

As reviewed in Chapters 3 and 5, the frontier approaches require data on inputs and outputs of banks. The data used in this study are obtained from the CBJ database and cover the period 1993-2006. The data comprise all the banks (domestic and foreign) operating within Jordan and cover the period both before and after the liberalisation process: this allows us to test the impact of liberalisation on the Jordanian banks' efficiency.

1.5 The Outline of the Study

The current study is structured as:

Chapter 2: Productive Efficiency: Theory and Measurement

This chapter introduces the theoretical framework related to the efficiency concept and draws attention to the difference between optimal and relative efficiency. This chapter reviews the traditional neo-classical theory of the firm that views the firm as a rational entity seeking to maximise profit. This theory ignores the internal structure of the firm and tries to explain how the market works rather than to understand the functioning of the firm itself. This theory also ignores the possibility of the internal inefficiency of the firm. Alternative theories and approaches such as X-efficiency, managerial discretion theory, principal agent theory and behavioural model are then briefly discussed. These theories focus on the internal structures of the firm and aim to explain why some firms may not operate efficiently. Moreover, this chapter introduces frontier efficiency as a tool used to measure efficiency within the context of economic theory, which is focused on the production activity as an optimisation process. This chapter reviews the main types of efficiency concepts in the economic theory (i.e. technical, allocative and economic efficiency). Parametric and nonparametric frontier approaches are also reviewed as these approaches enable one to measure the efficiency of a firm relative to other firms in the same industry.

Chapter 3: Efficiency in the Banking Industry: Empirical Evidence

This chapter draws attention to the importance of the banking system in the process of economic development and growth, and that a more efficient banking system is more qualified to lead the economic growth and development. This chapter outlines different arguments about whether the 'regulated' or 'market-based' banking system performs better and then promotes development and economic growth. The advantages of using frontier analysis within the banking industry as a measure of performance based in economic theory rather than using simple ratio analysis is discussed in this chapter. Since frontier analysis requires identifying banks' inputs and outputs, different approaches to specifying them are reviewed. Finally, the empirical literature on the efficiency of banks on different areas such as the impact of deregulation on banks' efficiency in different countries and different time periods is reviewed in this chapter.

Chapter 4: Jordanian Banking Industry 1993-2006

This chapter presents a brief historical overview of the banking system in Jordan. It highlights the main measures put in place to deregulate it. The structure of the Jordanian banks' balance sheet and income statement is reviewed for the period 1993-2006 to show how the deregulation measures affected it. Moreover, this chapter shows the performance of the Jordanian banks based on financial ratio analysis and outlines the development of competition in the Jordanian banking market.

Chapter 5: Methodology and Data

The chapter outlines the stochastic frontier approach (SFA) and data envelopment analysis (DEA) as frontier approaches used to measure efficiency levels of Jordanian banks. The variables to be used in this study are then described. This chapter also presents the model specification that involves estimating many models with different combinations of variables and the structural test employed to obtain the preferred model to measure efficiency levels for Jordanian banks. According to the preferred model, three distinct economic efficiency concepts (cost, standard profit and alternative profit efficiencies) are estimated to a single data set.

Chapter 6: Analysis and Discussion.

This chapter presents the preferred cost/profit model(s) obtained and the hypotheses (e.g. foreign ownership vs. domestic ownership) tested, using the preferred model(s). The efficiency scores over the period 1993-2006, from the preferred model(s) are estimated and analysed to see if and how the efficiency scores have changed over time. This gives an indication of the extent to which the steps taken by the CBJ have affected positively or negatively the banks' efficiency level. This chapter shows the robustness test for efficiency scores obtained from DEA and SFA by applying Bauer et al. (1998) criteria. This chapter draws attention to the difference between more and less efficient banks in terms of some indicators such as ownership structure, specialisation, bank size, non-performing loan level and capital adequacy ratio, return on equity, return on assets and cost income ratio. Finally, this chapter reports scale efficiency and technological change for Jordanian banks during 1993-2006.

Chapter 7: Conclusions

This chapter summarises and concludes. The main findings of the present study are outlined. Some policy implications are discussed. The limitations of the study and future research are also highlighted.

Chapter 2 Productive Efficiency: Theory and Measurement

2.1 Introduction

The aim of this chapter is to introduce the theoretical framework related to productive efficiency and frontier efficiency. The chapter also seeks to explain different approaches that can be used to measure a firm's efficiency. Section 2.2 presents a basic description of the concept of productive efficiency and draws attention to the difference between optimal and relative efficiency. Also, this section highlights the fact that neoclassical theory views the firm as a unified rational economic agent and profit maximisation is the only determinant of a firm's behaviour. This theory seeks to explain the way the market works, rather than to understand the internal efficiency of the firm and the function of the firm itself. In addition, the section shows how the market structure may affect the internal efficiency of the firm. It also reviews alternative theories which focus on the internal structures of the firm, and aims to explain why some firms may not operate efficiently by not seeking profit maximisation or cost minimisation behaviour. Section 2.3 introduces frontier efficiency as a tool used to measure efficiency within the context of economic theory which is focused on production activity as an optimisation process, using maximum production, minimum cost and maximum profit as tools. Moreover, this section reviews the main types of efficiency concepts in economic theory, namely technical, allocative, cost, profit, scale and scope efficiency. These concepts (except scope efficiency) will be referred to later in the empirical chapter of the thesis where efficiency levels in the banking sector of Jordan are analysed. Section 2.4 describes the main approaches (i.e. parametric and nonparametric) used to measure the main types of efficiency. The focus have is mainly on cost and profit efficiency as this methodology will be used later to estimate efficiency levels in the Jordanian banking industry. Also, this section shows the main differences between the two approaches used to measure firm's efficiency. Finally, section 2.5 presents a discussion on different functional forms used in the estimating cost and profit functions.

2.2 Internal Productive Efficiency and the Theory of the Firm

One of the key objectives of any economic system is ensuring efficiency in production (Lovell, 1993). The concept of efficiency refers to the use of limited resources in the best possible way to produce a maximum level of output. Baumol and Blinder (1982) defined efficiency in general as the absence of waste in the resources. Traditionally, economists have focused on the macro dimensions of efficiency (i.e. allocative efficiency). This is in terms of how market economies allocate scarce resources efficiently by using the price mechanism[1]. Goddard et al. (2001) defined allocative efficiency[2] as the production of goods and services most valued by society to meet consumers' needs in the best possible way. In contrast, practitioners and managers focus on the internal efficiency of a firm in terms of its production (i.e. the micro dimensions of efficiency). That is, they are more concerned with how firms transform resources into various outputs. Efficiency indicates that resources are not wasted and a firm is producing the maximum feasible level of output from these resources and using less costly combinations of such resources to produce a particular mix of products or services (Wheelock and Wilson, 1995).

Efficiency is recognised in the relevant literature as being achieved in two ways. Pareto-Koopmans[3] efficiency (optimality) is achieved when full (100%) efficiency reached by a firm, in inputs or outputs, can not be improved without worsening some of its other inputs or outputs (Thanassoulis, 2001; Ray, 2004). This optimal efficiency is an absolute term, but in most management and social science applications/research how to achieve such levels of efficiency, is not known (Cooper et al., 2007). Therefore, reference to such levels of efficiency in the literature on firm efficiency is replaced by

[1] The price mechanism is a system of determination of prices and resource allocation and it operates in a competitive market where forces of demand and supply guide prices. Both producers and consumers base their respective production and consumption plans on the prevailing market price. When consumers pay a price for a commodity, they motivate the producer of that commodity and hence more of the same is produced and vice versa (Baumol and Blinder, 1982).

[2] In the context of this research, allocative efficiency will refer to how firms use the right mix of input/output combinations relative to their prices rather than the allocation of resources by market forces using the price mechanism

[3] Vilfredo Pareto was concerned with welfare economics for customers; he formulated the so-called Pareto condition of welfare maximisation by noting that such a function could not be at a maximum if it was possible to increase one of its components without worsening other components of such a vector-valued function. Tjalling Koopmans adopted these concepts to production by referring that it was possible to increase any output without worsening some other output (Cooper et al., 2007). Their approaches were conceptual. No empirical application is reported before the appearance of Farrell's (1957) work, which showed how their approach could be applied to data to arrive at relative efficiency evaluation.

that of relative efficiency, in accordance with the available data and information on the performance of firms (banks). Relative efficiency (100% efficiency on the basis of comparison with available evidence on the performance of other firms) is achieved when the performance of other firms does not show that some of its inputs or outputs can be improved without worsening some of its other inputs or outputs (Zhu, 2002). Hence this second level of efficiency is considered as relative, rather than absolute, as it measures the performance of a firm relative to the best performance of other firms in a similar industry (i.e. a benchmark for performance).

Given that relative efficiency of a firm is a measure of its performance compared to that of the best in the industry, such a measurement of efficiency has implications for public policy and managerial performance, in terms of understanding how to achieve best practice. The principal objective of measuring the efficiency of a firm is to explore hypotheses concerning the sources of inefficiency or productivity differentials among other firms in the same industry (Lovell, 1993). Identifying sources of inefficiency in the performance of firms would help policy makers to design appropriate policies to improve performance (Lovell, 1993). Moreover, the performance of an economy depends on the performance of micro economic units, such as firms, in the sense that the enhancement of the efficiency of firms will contribute positively to enhance and enduring economic growth (Lovell, 1993).

Cummins and Weiss (1998), and Fried et al. (2007) argued that, in many cases, the measurement of firms' efficiency is a useful way to quantify performance differentials predicted qualitatively by economic theory. For instance, how a firm performs and conducts its business is influenced in the structure of the market in which it operates (Goddard et al., 2001). There is a common belief that in a competitive market, efficiency in terms of productivity is a key to survival, while it is not in a non-competitive market (Lovell, 1993). Thus, the measurement of relative efficiency would help policy makers in deciding what type of market structure, in terms of cost and availability of services, might best serve the public (Molyneux et al., 1996). For example, if the market is characterised by a high degree of concentration (dominated by few firms/institutions) and a large number of inefficient firms, this might indicate to policy makers the need to reduce entry barriers to that market, in order to foster competition that would alleviate such concentration.

At the managerial level, identifying best and worst practices (i.e. best and worst performing firms) is a useful tool to improve management practice and performance. Management practices found to be relatively efficient may be identified as best practices, to be adopted. In addition, managers can adjust their policies and procedures to avoid worst practices that are relatively inefficient (Berger and Humphrey, 1997). Furthermore, owners and managers may pay particular attention to the negative and positive determinants of efficiency by enhancing the positive determinants and avoiding or eliminating the negative determinants.

2.2.1 Economic Theory and Efficiency

The concept of productivity efficiency flows directly from the microeconomic theory of the firm and the production function is the most basic of such a concept (Cummins and Weiss, 1998). The production function lies at the heart of the theory of the firm. Broadly speaking, production is a series of activities by which inputs (resources) are transformed through various processes into output (goods or services). In other words, the production function is defined by efficient transformation possibilities depending on the available technology (Ganley and Cubbin, 1992; Cummins and Weiss, 1998). The production function represents the boundaries at which the firm reaches its technical production capabilities (Cohen and Cyert, 1975). If a firm is not operating at its production function capabilities, then it can not produce maximum output. The relationship between input-output, which underlines the production function, is viewed as a purely technical relationship. That is, the production function represents the maximum rate of output that can be produce with given inputs and technology. This relationship can be expressed as follows:

$$y = f(x_m) \tag{2.1}$$

where y represents output, x_m (m = 1, 2,...,M) is a vector of inputs and $f(.)$ is a functional form. Despite the economic theory's usually having little or nothing to say about the functional relationship in 2.1, it assumes the functional form of the relation between output and inputs should satisfy many properties (Sauer et al., 2006). These are summarised by Coelli et al. (2005, p. 12) as follows:

1. Non-negativity: this means the value of $f(x)$ is a finite, real and non-negative number.
2. Weak essentiality: this means the production of positive output is impossible without the use of at least one input. The function curve begins at origin because x is an essential element in the production process, so if $x = 0$ then $y = 0$.
3. Non-decreasing in x: this means additional units of an input will not decrease output. Thus, if $x_2 \geq x_1$ then $f(x_2) \geq f(x_1)$. This property implies that all marginal products of input are non-negative.
4. Concave in x, (the law of diminishing marginal productivity): this implies that the relationship between x and y is not linear. The law of diminishing marginal productivity[4] represents that as the amount of variable input (x) is increased by equal increments, a point will be reached where the increase in the output quantity will get smaller and smaller. In other words, as more variable input is added, the shape of the production function will begin to concave towards the x-axis.

Duality theory[5] establishes the relationships among production function, cost function and profit function (Coelli et al., 2005). It is underlined by achieving minimum production cost (minimum input cost) and maximum profit function. When data on prices for inputs and outputs are available and a firm is operating in a competitive market and its aims are to achieve cost minimisation or/and profit maximisation, then it is possible for a firm to decide on the best mix of inputs or/and outputs meeting such aims. The cost function is the one that can be interpreted as being derived from minimising cost subject to the constraint of a reasonable production technology. The cost function can be expressed as follows:

$$TC = f\,(w_n, y_k) \tag{2.2}$$

[4] Marginal product of inputs can be defined as ratio of variation in maximum possible output to variation in quantity of one input, by holding all other inputs' quantities constant. Mathematically, this procedure represents the partial derivative of the production function (y) with respect to one variable of inputs (x_1). In symbols, $\partial y / \partial x_1$.

[5] Generally speaking, duality theory is a mathematical technique concerned with translating concepts, theorems or mathematical structures into other concepts, theorems or structures, in one-to-one fashion (Sydsaeter and Hammond, 1995).

where TC variable total costs, w_n (n=1,2,...,N) represents a vector of input prices and y_k (k=1,2,...,K) represents the given level of outputs. Like the production function, the cost function should satisfy many properties, summarised by Coelli et al. (2005, p. 23) as follows:

1. Non-negativity: this implies that the costs can never be negative.
2. Non-decreasing in w: this implies an increase in input prices will not decrease costs.
3. Non-decreasing in y: this implies it costs more to produce more output.
4. Homogeneity: this implies the proportionate increase in inputs prices has resulted in the same proportionate increase in the variable costs.

Similarly, the profit function can be interpreted as the result of maximising profit subject to the constraint of reasonable production technology. The profit function can be expressed as follows:

$$NP = f\,(w_n, p_r) \tag{2.3}$$

where NP is the net profit, (which is revenue minus cost), p_r (r=1,2,...,R) is a vector of output prices and w_n is a vector of input prices. As with the cost function, the profit function should satisfy many properties which are a generalisation of cost properties. Some of the properties of the cost and profit functions will be referred to in the analysis and discussion chapter where we analyse the estimated cost and profit functions.

2.2.2 Competitive Model and Efficiency

As shown earlier, the production/cost/profit functions represent relationships between the factors of production (i.e. inputs) and corresponding outputs. These relationships aimed at optimisation behaviour are based on producing the maximum output that can be obtained from any given input (or alternatively, the minimum cost required to produce any given output) (Stevenson, 1980). The neoclassical theory[6] which is characterised by a perfect model, assumes that profit maximisation is the only determinant of a firm's behaviour (Cyert and Hedrick, 1972). The theoretical framework of perfect competition is based on reaching a long-run equilibrium position (Baumol

[6] Campus (1987) defined neoclassical economics as a general approach in economics focusing on the determinants of prices, output, and income distribution in markets through supply and demand.

and Blinder, 1982). Under perfect competition, no one firm can influence prices and all players in the market (buyers and sellers) have perfect knowledge about all products and their prices (Goddard et al., 2000).

The main characteristics of a market under perfect competition are:

1. A large number of firms in the market so that no single firm is able to exercise any significant influence on prices and all firms produce homogeneous products.
2. All firms and buyers have a perfect knowledge of prices set by all firms and all firms face horizontal demand curve.
3. The production technology is available to all firms in the market and the availability of resources in market is not restricted.
4. There are no entry or exit barriers in the market.

Goddard et al. (2001) pointed out that if all the above conditions are satisfied, then there exists a competitive equilibrium in which all firms earn normal profit, the minimum profit necessary to attract and retain firms in business. Under the perfect competition model, the behavioural assumption of a firm is to maximise profit (Goddard et al., 2001; Zamagni, 1987). The firm can maximise its profit in the long run by determining the optimal mix of inputs by equating the marginal product (MP) and marginal cost (MC) and output is determined when marginal revenue (MR)[7] equals marginal cost (MC) (i.e. where the revenue raised from selling an extra unit is equal to the cost of producing that extra unit). At the point where MR=MC, the firm is considered to have allocative and productive efficiency (Griffiths and Stuart, 2001). The allocative efficiency occurs because the price is equal to marginal cost, at which point the good is available to the consumer at the lowest possible price. Productive efficiency is achieved because the producer is minimising the cost of production by producing at the minimum point on its average cost curve (Griffith and Stuart, 2001). Since the information in the market is available to all producers and there are no transaction costs associated with the re-allocation of inputs, firms can achieve the optimal allocation of their resources to produce the maximum level of output. For the neoclassical theory, a firm must operate

[7] Under perfect competitive model, the marginal revenue of a firm is equal to the price and the firm can sell as much as it wants at the going market price, which implies that the firm is facing a horizontal demand curve. The reason behind that is that the size of the firm is very small relative to the market and does not have any effect on the price (price takers).

efficiently as the capital markets will penalise inefficient firms by depressing thier share prices and subjecting them to takeover, or to drive out of the market by efficient firm. Also, Machlup (1967) argued that there is no scope for slack (e.g. waste resources) if a firm operates in a perfectly competitive market since a firm that does not minimise cost will eventually be driven out of the market. Additionally, some authors such as Vives (2001) argued that competition enhances productive efficiency by reduction of slack management; the pressure of the competitive market gives managers the incentives to perform and provides information to design appropriate incentive schemes that could prevent the firm from liquidation or being driven out of the market. Thus, efficiency in the competitive model is solely a function of the market (Cyert and George, 1969). However, the literature on firm efficiency suggests that firms can not always operate efficiently, as assumed by the neoclassical theory, due to many factors (discussed later in this chapter). Rather, the literature also shows that firms can still continue to work in the market, despite being inefficient. The view of the firm in the neoclassical theory as a rational economy entity and must be operated efficiently is not always the case (Machlup, 1967). In addition, Williamson (1975) argues that the notion of optimality in the neoclassical theory is arbitrary, since it is based on the absence of transaction costs (e.g. the cost of acquiring information) and the rationality of the producer. However, in reality, transaction costs are an integral part of the production process, while decision making can be irrational and imperfect, underlined by the failure to consider all available options and compare them to each other. Machlup (1967) points out that neoclassical theory seeks to explain the way the market works, rather than to understand the function of firms themselves.

2.2.3 Market Imperfections

As discussed earlier, the competitive model assumes that there are a large number of firms in the market so that no single firm is able to exercise any significant influence on prices and all firms produce homogeneous products. Rather, in reality, some industries are dominated by a few large firms that may have control over prices charged and therefore can earn abnormal profits. Thus the neoclassical theory has been made to take into account different market structures that may result in some firms operating inefficiently. When the market is not perfectly competitive, then the market structure is imperfectly competitive and the degree of imperfect competition is dependent on the number of the firms operating in market. The extreme case of imperfect competition is monopoly, which was formulated by Sraffa (1926). Monopoly exists in a market for two basic reasons: (1) barriers to entry: exclusive knowledge of a given productive technique, owning the resource of production and patents and legal restrictions imposed by government to protect a specific sector from competition; (2) cost advantages of large-scale operations (Baumol and Blinder, 1982). Thus a competitive mechanism is blocked under a monopolist market. Like any other firms, the monopolist maximises its profit by setting marginal revenue (MR) equal to marginal cost (MC). However, because the monopoly firm faces a downward sloping demand curve, this means that the MR of the monopolist is less than the demand curve (average revenue or price), the monopolist can maximise profits when the price exceeds marginal costs and the firm can make super-normal profits. The ability of the monopolist to set higher prices is because the absence of barriers to entry can result in a restriction of output relative to the competitive level and thereby a misallocation of resources (Berger and Hannan, 1998; Baumol and Blinder, 1982).

Early economic theory had only two workable models of the behaviour of firms: the perfectly competitive and the monopoly models. These two models are very theoretical and could not represent all the types of market structure that existed between the perfectly competitive model and the monopoly model. The work of Chamberlin and Robinson (1930) filled this gap by introducing other types of market structures, namely monopolistic competition and oligopoly (Baumol and Blinder, 1982; Goddard et al., 2001). Monopolistic competition has many characteristics similar to the competitive model (e.g. all firms and buyers have a perfect knowledge of prices set by all firms) except that the firms produce heterogeneous products, whereas the firms under perfect competition produce homogeneous products. Thus, since firms in monopolistic competition are able to differentiate their products, a certain freedom exists in fixing the selling price for products they offer and they face a downward sloping demand curve.

The other kind of market structure introduced by Chamberlin and Robinson is oligopoly. An oligopolistic market is characterised by a few firms which supply the market and realise that they are interdependent in their pricing and output decisions (Livesey, 1998). An oligopoly differs from perfect competition because each firm in an oligopoly has to take into account its interdependence. Analysing resource allocation under oligopoly is not a simple task because of the interdependent nature of the oligopolistic decision (Baumol and Blinder, 1982). For example, if one firm announces a price change, competitors take quick notice and change their price. Consequently, competition is highly personalised, with each firm recognising that its own best course of action depends on the strategies of its competitors (Thompson, 1989). A change in output by one firm will alter the profits of competitor firms and cause them to adjust their output (Goddard et al., 2001). Competition under oligopoly ranges from vigorous price competition, which can lead to substantial losses, to implicit or explicit forms of collusion (Goddard et al., 2001). In the case of implicit and explicit collusion, firms in an oligopolistic industry may try to be like a monopoly by restricting industry output and raising prices in order to earn abnormal profit. Thus, firms in an oligopoly industry could exercise market power by setting their price above marginal cost and producing less output (Livesey, 1998). That is, the firms are not efficient in the allocation of resource.

The above discussion shows that four basic (theoretical) market structures are described by neoclassical economic theory: perfect competition, monopoly, monopolistic competition and oligopoly. These four structures define the number and the size distribution of the firms, the type of product produced, the extent of control over prices by firms, and the ease with which firms can enter or exit markets (Goddard et al., 2001). Additionally, Berger and Hannan (1998) stated:

> "*Market structure may influence efficiency for one of several reasons. First, if high levels of market concentration allow firms to charge prices in excess of competitive levels, then managers may take part of the benefits of the higher prices not as higher profits, but in the form of a "quiet life"*[8]*, in which they don't work as hard to keep costs under control. The difference between the actual price and the competitive price may provide a "cushion" or comfort zone. In the absence of other disciplining mechanism, managers may allow unit cost to rise to consume part of this cushion and still allow owners to earn economic rents without the full effort of cost minimisation. Second, market power may allow managers to pursue objectives other than firm profits or managerial leisure. Third, the price cushion provided by market power may simply allow inefficient managers or practices to persist*

[8]The Quiet Life Hypothesis was developed by Hicks (1935). This hypothesis assumes that a firm with greater market power will be more risk averse, and that it will be able to achieve some combination of both higher return and lower risk than firms possessing lesser power in the market. Berger and Hannan (1998) provided a test of the quiet life hypothesis in US banking and found that the concentrated market exhibited relatively low cost efficiency

> *without any intention to pursue goals other than maximising firm value. The lack of market discipline in concentrated markets may simply blunt the economic signals that would normally force changes in management to keep costs low, leaving managers in a position for which they do not have comparative advantages. Thus, market power may allow managerial incompetence to persist without any wilful shirking of work effort, pursuit of other goals, or efforts to defend or obtain market power" (p.455).*

That is, if the market is characterised by high concentration which allows firms to charge prices in excess of the competitive price, managers of firms will benefit from such high prices by not operating efficiently and being interested in a quiet life, in which they do not work hard to keep costs under control[9] (Berger and Hannan, 1998).

2.2.4 Why Some Firms may not Operating Efficiently?

The neoclassical theory of the firm seeks to explain how the market works (i.e. the firm is a mere production function converting inputs to outputs), rather than to understand the functioning of firms themselves or their internal structure (Machlup, 1967). Although the neoclassical theory takes into account various market structures, it still assumes that the decision making process within the firm is rational and aiming to maximise profit. The neoclassical theory is challenged by alternative theories and hypotheses, such as X-efficiency hypothesis (Leibenstein, 1966), managerial discretion theory (Williamson, 1964), principal agent theory (Jensen and Meckling, 1976) and behavioural theory (Simon, 1955; Cyert and March, 1964). These theories focus on the internal structures of the firm and aim to explain the factors that could make some firms operate inefficiently by not seeking profit maximisation or cost minimisation behaviour.

[9] Traditionally, public policy has been concerned with the concentration in a specific industry and has focused on the social loss associated with the exercise of market power at a high level of concentration (Berger and Hannan, 1998). The setting of the price in the concentrated market above the price level in the competitive market brings about a restriction on output level. The social loss associated with this misallocation is called deadweight loss. The deadweight loss represents the differences between the loss in consumer surplus and the gain in producer surplus associated with monopoly pricing (Berger and Hannan, 1998). Empirical studies have found the social loss associated with exercising market power is trivial. For example, Harberger (1954) reported that the elimination of monopoly resource misallocation in manufacturing during the period 1924-1928 would have increased social welfare by less than 0.1% of gross national product (GNP). Also, Rhoades (1982) reported that the deadweight welfare loss due to monopoly in the U.S banking market is very small. For more studies measuring deadweight welfare loss, see Leibenstein (1966). In the context of this research the concern will be on the impact of concentration on the internal efficiency of banks.

1. X-Efficiency

The terminology of X-efficiency was developed by Leibenstein (1966) to describe why economic agents may not achieve maximal efficiency in their productive decisions and behaviour (Button and Weyman-Jones, 1992). He named it 'X' to emphasise that the precise nature of inefficiency is not known (Frantz, 1992). Within his X-efficiency hypothesis, Leibenstein (1966) stated that the basic decision–makers in firms are individuals who, through their efforts and choices determine cost of production. The utilisation of the resources depends basically on the level of effort of individuals within the firm. The variation of this level of effort depends on many factors, such as internal (e.g. pressure from managers on individuals) and external (e.g. pressure due to increasing competition). Leibenstein (1966, 1975, and 1979) argued that the neoclassical theory of the firm, which views firms as a production function, did not explain why firms do not operate efficiently. Leibenstein (1966) focused on the following sources of inefficiency. First, inadequate motivation stemming from a weakness of competitive pressure. That is, the lack of competitive pressure may lead a firm to neglect minimising unit cost of production, due to having a great amount of wasteful expenditure, such as maintenance of excess capacity and luxurious executive benefits. Second, the X-efficiency hypothesis assumes that employee contracts are incomplete in that pay in an employment contract is clearly determined, how much effort an employee exerts is not. Because of this incomplete contract, workers have freedom over how much effort they put into their work (Frantz, 1992). The X-efficiency hypothesis views the individual as the basic unit in the firm, rather than the firm that is a unified entity striving to maximise profit. Third, the agency problem, which refers to the conflict of interest between agents (managers) and principals (owners). Fourth, asymmetric information which assumes that at least one party to a transaction has relevant information that is not available to others. The X-efficiency theory hypothesis, states that:

> *"Neither individuals nor firms work as hard, nor do they search for information as effectively as they could." (Leibenstein, 1966, p. 407).*

The degree of X-inefficiency, as described by Leibenstien (1975), is equal to the difference between maximal effectiveness of utilisation of inputs and actual utilisation of inputs.

2. Managerial Discretion Theory

Williamson (1964) suggested that as a result of the separation of management and ownership and a lack of competition, managers would seek to pursue their own self-interest. Although managers do aim to maximise profits, Williamson (1964) assumed that managers controlling the firms are in a position to divert profits from the owmers for their benefits indirectly. Managers cannot cut into profits after the fact, that is, after they have been declared (Leibenstein, 1966). But they can lower profits by increasing expenses. Thus, Williamson (1964) implicitly assumes there exist expenses which are for the benefit of managers (e.g. lavish furniture, excess staff expenditures) (Cohen and Cyert, 1975). If the top management is able to achieve an acceptable level of profit and show a reasonable rate of growth over time and sufficient dividends are paid to the stockholders to make them satisfied, then the managers can guarantee keeping their power and control over the firm. The expenses' preferences hypothesis, stemming from managerial discretion theory, can be defined as the satisfaction accruing to managers from their discretion in matters relating to expenditure (Zamagni, 1987). The expenses' preferences hypothesis[10] (slack management) views the firm as maximising utility through the chasing of non-profit maximisation behaviour. Under this hypothesis, managers seek to increase staff expenditures and managerial compensations (Williamson, 1964).

3. Principal Agent Theory

Another problem stemming from the separation between management and ownership is the principal-agent problem. Jensen and Meckling (1976) define an agency relationship as a contract between the principal (owner) and the agent (manager). According to the contract, a principal appoints another person (agent) to perform some services on behalf of the owner, which involves delegating some of the owner's authority to a manager. If an agent is a utility maximiser, there is good reason to assume the agent will not always act to maximise profits as the principal might wish; rather, the manager will seek to maximise his/her utility. However, the principal can limit the aspiration of the manager by establishing an incentives system for the agent that could reduce the managers'

[10] Edward (1977) and Hannan and Mavings (1980) investigated the expenses preferences hypothesis in the banking industry. They found that wages and salary expenditures in banking increase with monopoly and oligopoly power. Also, their results showed that the banking market industry is dominated by market imperfection (monopoly and oligopoly). Both authors indicated that an expenses preferences hypothesis is the appropriate model to describe and predict bank behaviour rather than the profit maximising model.

aspirations. Also, the principal may incur monitoring costs (i.e. internal and external auditing systems reporting directly to the owner) to limit the activities of the manager which are not consistent with the principal's goals. The costs generated from the owner to limit the agent's aspirations are called agency costs, which include excessive operating costs and lost revenues. These costs could provide an explanation for the differences in the performance of firms operating under different ownership types (Cummins et al., 2004). Fama and Jensen (1983) argue that the principal-agent problem would be a noticeable problem in the firm unless there is a system of compensation packages or external corporate control mechanisms that could align the objectives of the managers and shareholders. Under the principal-agent regime, the managers are likely to be increasing their perquisites or pursuing non-optimal growth strategies to maximise their utilities. The separation of the management decision from the control decision could help to alleviate the agency problem (Fama and Jensen 1983). Chief Executive Officers (CEOs) of the firms are usually endowed with the most power in the decision management process, in the sense they are highly engaged in the preparation of the investment projects and their follow-up implementation (Pi and Timme, 1993; Isik et al., 2003). Whereas the Board of Directors, led by the chairman, is generally endowed with the most decision control, in the sense that the chairman and board typically approve policies which define criteria and terms for investment decisions that will emanate from the CEO. However, when the CEO is also the chairman of the board, principal-agent conflicts may be increased as a result of the concentration of decision making and control in one person (Isik et al., 2003). The ownership/management relationship is an important element in the operation of firms. The motivation and goals of firms' management and stockholders may be a major determinant of the firm's efficiency and performance and such factors may differ widely from one firm to another (Spong et al., 1995).[11]

4. Behavioural Model

An understanding of the internal structure of the firm and the process of decision taking within it may help to explain why firms are not operating to maximise profits. The

[11] The relationships between ownership structure and firm efficiency have been analysed in the banking industry by several authors, for example see Pi and Timme (1993); Isik and Hassan (2003); Berger and Hannan (1998) ; Spong et al. (1995); Glaasman and Rhodes (1980). Most of these studies reported a negative relationship between the level of bank efficiency when the CEO and the chairman are the same person.

behavioural approach was developed and analysed by Simon (1955) and Cyert and March (1963). It aims to explain how decisions are taken within the firm. The behavioural approach examines the effects of variables internal to the firm on price and output decisions (e.g. goals of different parties). The traditional theory, however, ignores the internal structure of the firm and assumes that market factors dominate in relation to price and output decisions (Cohen and Cyert, 1975). Simon (1955) suggests a theory of human choice and decision making and concentrates on the decision-making process mechanism within each firm. Simon proposes that the process could be contradicted by rational aspects of choice that have been the principal concern of economists. Cyert and March (1963) view the firm as a coalition of various groups (managers, workers and stockholders, clients, suppliers, banks and government) which are linked to the firm's activities in different ways. Each group in this coalition has its own objectives. For example, workers want high wages, good working conditions and good pension rights; managers want high salaries and more power and prestige (Zamagni, 1987).

As discussed earlier, the neoclassical theory of the firm views firms as having only one objective, which is profit maximisation, whereas behavioural theory views them as a coalition of many parties with conflicting objectives. Therefore, the behavioural theory emphasises the formation of the goals of the firm through a bargaining process among the various parties of the coalition. Thus, in contrast to the neoclassical approach, the firm under the behavioural theory has more than one objective. Cohen and Cyert (1975) stated that setting many conflicting objectives for the firm could bias its decision regarding cost and revenues estimation.

Finally, it is worth referring to the work of Alchian and Demsetz (1972) who suggest that the essence of the firm is that it permits people to work as a team. They propose that in a firm a failure to reward without regard to the productive effort of individuals will distort the incentives to engage in any productive effort. Thus, according to Alchian and Demsetz (1972), the firm is required to measure input productivity and rewards. If a firm measures poorly, then productivity will be smaller. Alchian and Demsetz (1972) argued that under the neoclassical theory of the firm the inputs are allocated without cost, because they are allocated according to their marginal productivity. For Alchian and Demsetz, the firm therefore is an entity which brings together a team which is more productive working together than at arm's length through the market because of informational problems associated with monitoring of effort. In effect, therefore, this is a 'principal-agent' theory since it is asymmetric information within the firm which Alchian and Demsetz emphasise must be overcome.

To sum up, the neoclassical theory of the firm views the firm as a rational entity that is a mere production function converting inputs to outputs and failed to explain why firms are not operating efficiently. To overcome this, new theories focused on the internal structures of the firm and aimed to explain the factors that make some firms unable to operate efficiently, by not seeking profit maximisation or cost minimisation behaviour. The new theories are considering the firm as a nexus of contracts among various 'opportunistic' individuals who may not be 'rational' utility maximisers. The ability of firms to transform inputs into outputs in these theories is a function of internal specific variables (e.g. risk attitude, ownership structure, corporate control) and/or external factors (e.g. market conditions, government regulations).

In the context of this research, the market structure, managerial discretion, principal-agent and behavioural theories can be analysed from many perspectives in relation to Jordanian banks' efficiency level. First, in Jordan, an oligopolistic market structure reflects reality better than perfect competition and prices for deposits and loans for both banks and individual customers are more likely to be endogenously rather than exogenously determined (Isik et al., 2004). This means that banks in Jordan are operating in a concentrated market. The literature suggests that higher concentration is significantly associated with market power and that enables banks to set higher loan rates and pay lower deposit interest rates (Berger, 1995; Berger and Hannan, 1998; Berger and Humphrey, 1997). Also the literature and evidence suggest that banks working in a concentrated market are less efficient than those operating in a competitive market (Berger and Hanna, 1998).

Second, the ownership structure of Jordanian banks mainly consists of local and foreign banks. The variation in the ownership structure could play a vital role in determining the efficiency level of Jordanian banks. Moreover, there are three different groups of banks operating in Jordan: commercial, investment and Islamic banks. These different groups of banks could play a crucial part in explaining cross-sectional variations in bank efficiency.

Third, the CEO and the chairman are the same person in most Jordanian banks. Thus, the designation of the same person in two positions may have a negative impact on the efficiency level of the banks.

Finally, the banking culture in Jordan is one that is heavily reliant on ties and relationships (i.e. services are obtained quickly according to the degree of influence one has among staff (e.g. a friend/ relative). For example, a decision on making of loans is influenced by the close relationship/ family ties between the lender and the manager. However, such relationships/ways of doing business have led to the problems of bad loans. Bad loans in the bank could be a result of wrong decisions taken by the bank's management and reflect bad managerial practice/ behaviour. Based on the above, the level of bad loans[12] could play a vital role in explaining the differences in efficiency among Jordanian banks.

2.3 Frontier Efficiency as Measure for Performance

In section 2.2, it was shown that the economic theory focuses on production activity as an optimisation process. Theoretical production analysis has always focused on production activity as an optimisation process (Fare et al., 1994). Maximum production, minimum cost and maximum profit are tools presented as a solution to the optimisation process (Lovell, 1993). Also, the previous section suggests that the traditional theory of the firm does not explain why firms are not operating efficiently. Also, we reviewed some theories that aimed to explain this. However, to determine whether the firm is efficient or inefficient, an empirical analysis is needed to compare between the actual operations of the firm and some best practice. In this section, we introduce frontier analysis as a tool to evaluate the efficiency of firms. The contemporary empirical literature on the measurement of efficiency builds on the work of Farrell (1957). The following sections will discuss Farrell's ideas that formulated a basis for efficiency measurement within economic theory that focuses on production activity as an optimisation process.

The early empirical literature is based on the estimation of production, cost and profit functions using Ordinary Least Squares (OLS) regressions (Lovell, 1993). The function

[12] Berger and De Young (1997) and Kwan and Eisenbeis (1994) reported that level of problems loans and level of efficiency are negatively related.

estimated by OLS represents the line that intersects through data and estimates average performance. The resulting average function which represents the intersecting data with a function rather than surrounding data with a frontier is used as a measure of performance (Lovell, 1993). Ganley and Cubbin (1992) stated:

> *"The resulting average function is a misleading indicator of efficient production possibilities in both theory and practice. In practice, an average performance standard will tend to institutionalise inefficiency. This can occur because in reducing, what appears to be attainable, an average standard acts as a disincentive to further improvement in performance."* They add that *"An average production function is inconsistent with the theoretical notion of a boundary function which reflects maximising behaviour" (page 9).*

Given that the estimation of the production/cost/profit functions using OLS as a performance measure is not consistent with the theoretical notion of the optimisation process, the focus has turned to envelop the data by using production frontier (e.g. Aignar and Chu,1968; Afriat,1972; Richmond,1974). Thus the frontier methodology has become the function of analysis and interest in surrounding data has been replaced with the practice of intersecting data (Fried et al., 2007; Fare et al., 1994; Lovell, 1993).

Frontier and efficiency measurements started with the work of Farrell (1957) who introduced the first empirical treatment of the production function as a production frontier. He provided a measure of a firm's efficiency that could account for multiple inputs within the context of technical and allocative efficiency. The frontier efficiency considers efficiency as a relative, rather than as an absolute, and is concerned with comparing observed and optimal values of inputs (cost) and outputs (profit)(Coelli et al., 2005).

Aignar and Chu (1968) asserted that the production frontier is appropriate for ascertaining the maximum production capacity for a firm. That is, the main focus of the production frontier is to allow the maximum output that is technologically feasible to be attained. Under the production frontier approach, a firm's performance is measured relative to the best in the industry (Coelli et al., 2005). That is, the production frontier for all firms in the same industry is plotted and if a firm's actual production point lies on the production frontier, then the firm is considered efficient. However, if this production point lies below the frontier, then the firm is regarded as inefficient (Coelli et al., 2005). Equivalent interpretations hold for cost and profit functions for given input and output prices, which should be interpreted as a frontier function (Ganley and Cubbin, 1982). The measure of inefficiency is calculated by the distance from the point at which a firm lies below or above its production, profit and cost frontiers (Forsund et al., 1980).

2.3.1 Farrell's (1957) Efficiency (Technical and Allocative Efficiency)

Farrell (1957) suggested that the productivity efficiency of any given firm can be measured through technical and allocative efficiency. Technical efficiency(TE) refers to the ability of the firm to avoid waste by producing as much output as input usage allows or using minimum inputs as output production allows (Lovell, 1993). Thus, the analysis of TE can have an output or an input orientation. Evanoff (1998) refers to technical inefficiencies as the underutilisation or mismanagement of inputs, resulting directly from using excess inputs to produce a given level of outputs. He also stated that technical inefficiency can be attributed to weak competitive forces that allow inefficient firms to stay in the market.

However, when input and output prices are known and the aim of a firm is to minimise cost or maximise profit, then it is possible to select the optimal combination from inputs or outputs, to achieve such an aim. This optimal mix is known as allocative efficiency (AE)[13] (Farrell, 1957). Lovell (1993) defined AE as the ability of a firm to combine inputs and outputs in an optimal proportion, in the light of prevailing prices. As with TE, AE can be analysed from the perspective of input or output orientation (Lovell, 1993). Input-orientated allocative efficiency refers to the ability of a firm to select the right mix of inputs (i.e. achieve cost minimisation) in the light of prevailing prices to produce a given bundle of output. Output-orientated allocative efficiency refers to the ability of a firm to produce the right mix of output (i.e. achieve maximised revenue).

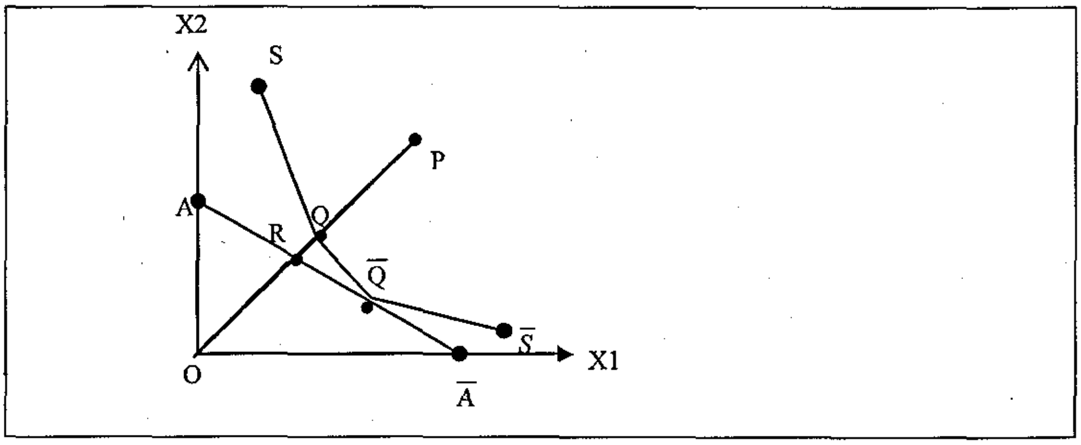
Farrell (1957) introduced measures of technical and allocative efficiency as the ratio of potential and actual performance based on the production frontier. A score of unity (i.e. actual equals predicted potential) refers to technically efficient, because no equiproportionate input reduction is possible. A score less than unity refers to technical inefficiency (Lovell, 1993).

[13] Farrell used the term price efficiency instead of allocative efficiency.

1. Input – Orientated: Technical and Allocative Efficiency

Figure 2.1 illustrates Farrell's measurement of input- orientated technical and allocative efficiency, using an example of firms using two inputs (X1 and X2) to produce a single output (Y), assuming constant returns to scale and a given level of technology.

Figure 2.1 Technical and Allocative Efficiency (input-orientated)



Source: Coelli et al. (2005, p. 52)

The isoquant curve[14] S $\bar{S}$ represents all the possible combinations of two inputs that can produce a given level of output. All the firms in the industry that produce to this given isoquant S $\bar{S}$ are technically efficient, where TE of the firm is the ratio of potential utilisation of inputs to the actual input consumption. Firms operating on the isoquant are considered technically efficient and those operating above it are regarded as technically inefficient. For example in Figure 2.1, if a firm is producing at point P the TE for this firm is equal to the ratio OQ/OP (potential /actual), which equals less than unity. Thus, this firm is technically inefficient and the distance QP represents the amount of proportional inputs that could be reduced without a reduction in output. Mathematically, TE is equal to:

$$TE = OQ/OP \tag{2.4}$$

where OQ represents the potential inputs used to produce a given output and OP the actual consumption of inputs to produce the same quantity of output that could be produced using less input.

[14] Assuming the unit isoquant of fully efficient firms is known and this isoquant represents the optimal utilisation of inputs. It should be noted that the efficient unit of isoquant is not known in practice and thus must be estimated from observation of a sample of firms in the industry concerned.

TE in equation 2.4 takes a value between 0 and 1, where 1 represents the optimal utilisation of inputs.

However, the concept of TE does not consider the prices of inputs and therefore does not consider whether firms in the industry are allocating their inputs according to their prices in the optimal proportion. Farrell therefore included an allocative efficiency (AE) ratio in his frontier framework. Using Figure 2.1, with the assumption that the prices of inputs are known and there is a competitive market for the purchase of these factor inputs (one of the assumptions of the model of perfect competition being that the production technology is available to all firms in the industry and the availability of resources is not restricted), the relative factor prices are incorporated into the isocost line $A\,\overline{A}$ which represents a combination of inputs which all cost the same. Therefore, as with TE, a score of unity refers to AE and a score less than unity measures the severity of allocative inefficiency. For example, at point Q in Figure 2.1, the AE of the firm is equal to the ratio of OR/OQ, which is less than unity. Although point Q is located on the isoquant, which means that this firm is technically efficient, it is not allocatively efficient and the distance RQ represents the potential reduction in the production costs. Mathematically, AE is given by:

$$AE = OR/OQ \tag{2.5}$$

where AE is allocative efficiency.

The point of tangency between the isoquant and isocost curves represents the minimum cost of producing a given output. Thus point $\overline{Q}$ (Figure 2.1) represents the point where the firm is allocatively and technically efficient. Point $\overline{Q}$ is also the combination that Bauer et al. (1998) called economic efficiency. To be economically efficient, a firm has to choose its inputs and mixes according to their prices so as to optimise an economic goal, usually cost minimisation. In the case of input-orientation, given the measure of technical and allocative efficiency, the total overall cost efficiency (CE) can be presented as a product of technical and allocative efficiency measures (Coelli et al., 2005):

$$CE = TE \times AE = (OQ/OP) \times (OR/OQ) \tag{2.6}$$

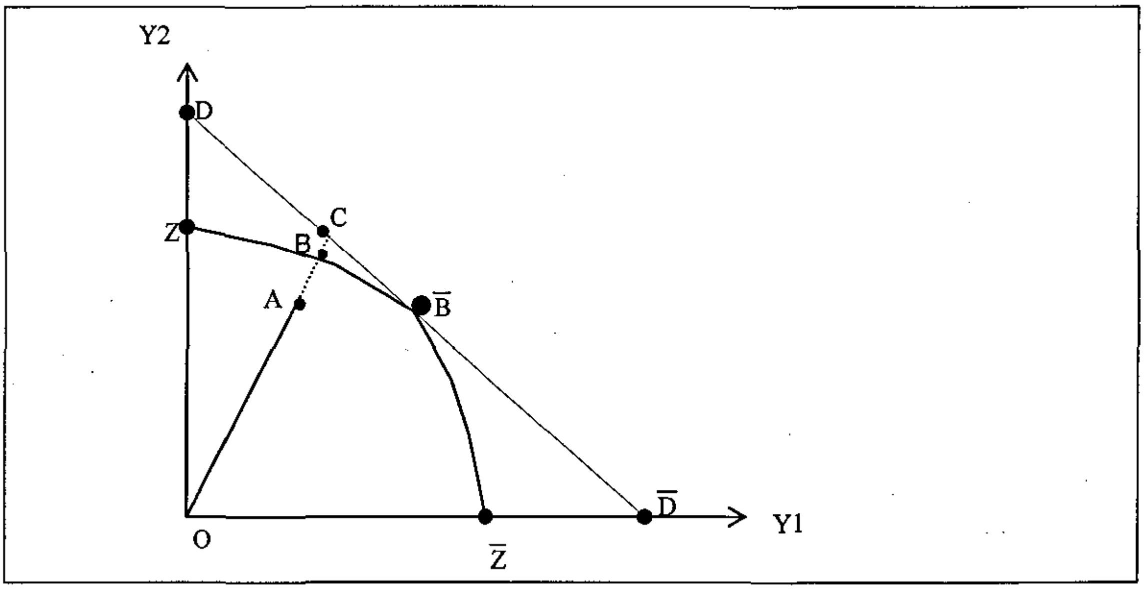
where CE is cost efficiency, TE is technical efficiency and AE is allocative efficiency.

2. Output-Orientation: Technical and Allocative Efficiency

The above discussion presented technical and allocative efficiency from the cost minimisation perspective, by addressing the question "How much can input quantities be proportionally reduced without changing the quantities of output produced?". Or, "What is the optimal mix of inputs according to their prices that can be chosen to produce a given output with lower cost?" (Coelli et al., 2005). One can also look at technical and allocative efficiency from the revenue maximisation perspective by addressing the question "How much can output quantities be expanded without changing the quantities of input?" (Coelli et al., 2005).

To address the latter question, output-orientation measures for technical and allocative efficiency, as shown in Figure 2.2, can be used. Figure 2.2 illustrates Farrell's measurement of output-orientated technical and allocative efficiency, using an example of firms with one input (X1) to produce two outputs (Y1, Y2), assuming constant returns to scale and a given technology.

Figure 2.2 Technical and Allocative Efficiency (output-orientated)



Source: Coelli et al. (2005, p.55)

The production possibility curve[15] ($Z\overline{Z}$) represents all the ways of producing two outputs using a given level of input. Thus, moving along the production possibility curve ($Z\overline{Z}$) represents the technically efficient output combinations and any combination of the two outputs below the production possibility curve reflects a technical inefficient condition of production. The TE of the firm is the ratio of actual outputs produced to potential output. Thus point A in Figure 2.2 corresponds to an inefficient firm and the technical efficiency of the firm is equal to OA/OB (actual / potential) which is less than unity. The distance AB represents the amount by which the two outputs can be proportionally expanded without affecting the level of input. Mathematically, output TE is given by:

$$TE = OA/OB \tag{2.7}$$

where OA represents actual production and OB represents potential production.

TE in equation 2.7 can take a value between 0 and 1, where 1 represents the optimal outputs firm can attain for a given level of inputs.

The concept TE does not consider the prices of outputs and therefore does not consider whether firms in the industry are allocating their outputs according to their prices in the optimal proportion. Farrell therefore included an AE ratio in his frontier framework. AE from an output perspective involves selecting the mix of outputs that maximise revenue with a given quantity of inputs. The isorevenue line ($D\overline{D}$) in Figure 2.2 represents a line depicting all combinations of two products that will generate a given, or same, level of total revenue. At a point such as B in Figure 2.2, the AE of this firm is equal to the ratio of OB/OC, which equals less than unity. Although point B is located on the production possibility curve which means that this firm is technically efficient but is not allocatively efficient. The distance BC represents the increase in the revenue that a firm could earn if it moved from point B to $\overline{B}$. Mathematically, AE from an output perspective is given by:

[15] A production possibility curve is a graph showing the different quantities of two goods that a firm could efficiently produce with minimum productive resources.

$$AE = OB/BC \tag{2.8}$$

where AE is allocative efficiency.

The point of tangency between the production possibility curve and the isorevenue curve represents the maximum revenue the firm can earn. Thus point $\overline{B}$ represents the point where the firm is both allocatively and technically efficient. As in input-orientation, economic efficiency is a combination of technical and allocative efficiency as at point $\overline{B}$. To be economically efficient, a firm has to choose output levels and mixes so as to optimise an economic goal, usually revenue maximisation. In the case of output orientation, the total revenue efficiency (RE) can be presented as a product of technical and allocative efficiency measures (Coelli et al., 2005):

$$RE = TE \times AE = (OA/OB) \times (OB/OC) \tag{2.9}$$

where RE is revenue efficiency.

2.3.2 Scale Efficiency

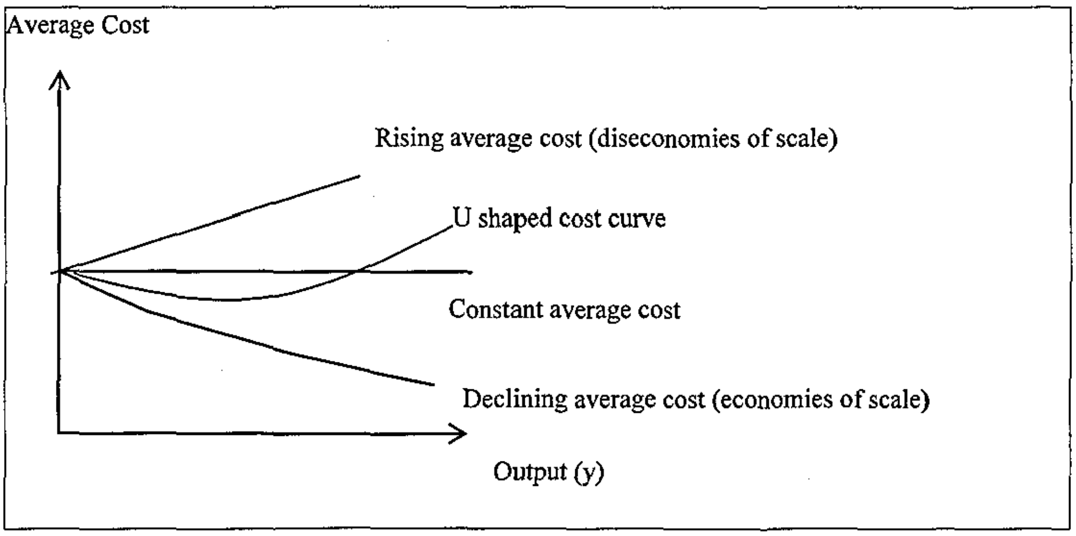
Section 2.3.1, discussed a firm's efficiency relating to the production technology frontier and at a given quantity of inputs and outputs and their prices. The firm may be described as efficient in terms of technical, allocative and economic efficiency, but the scale of its operation may still not be the optimal (Coelli et al., 2005). Economies of scale refers to the rate at which output changes, as all factor quantities are varied, and it measures whether firms with similar production and managerial technologies are operating at optimal economy of scale (Molyneux et al., 1996). An economy of scale is measured by the ratio of the proportionate change in output to a given proportionate change in all inputs/ average cost (Goddard et al., 2001). Economies of scale can be defined in terms of either the production function or the corresponding cost function. There are three situations describing the relationship between the change in input/average cost unit and the change in output:

1. If the proportional change in output is more than the proportional change in the input/average unit cost, a firm is said to be operating at *increasing* returns to scale.

2. If the proportional change in output is equal to the proportional change in the input/average unit cost, a firm is said to be operating at *constant* returns to scale.
3. When the proportional change in output is less than the proportional change in input/average unit cost, a firm is said to be operating at *decreasing* returns to scale.

Figure 2.3 shows the relationships between economy of scale and the shape of the long average cost curve. As the figure shows, a firm can minimise its production cost by producing at the constant returns to scale. Since raising the proportional change in output is equal to the proportional change in the input (average unit cost), a firm is said to be operating at constant returns to scale.

Figure 2.3 Economies of Scale and Shape of Average Cost

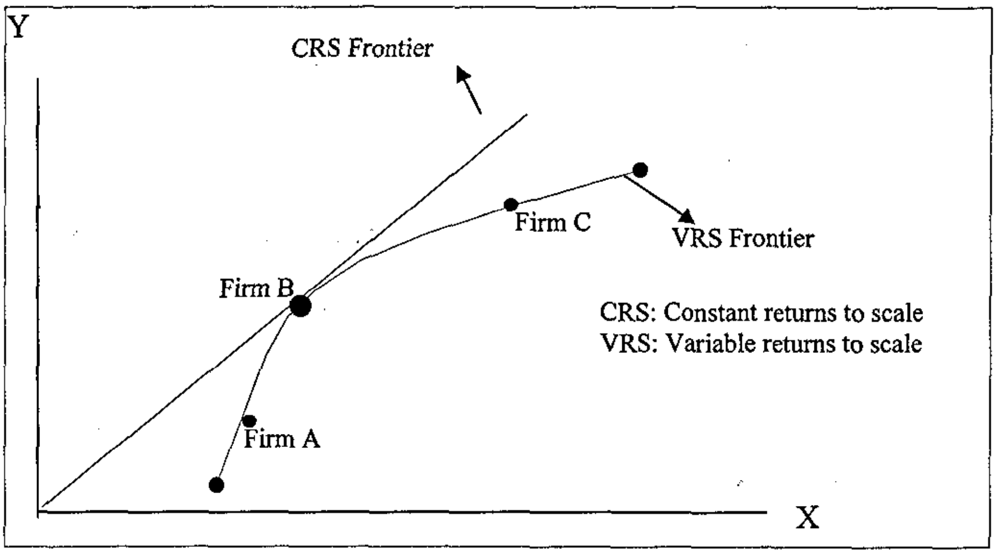


Source: Sinkey (1992, p.306)

Akhavein et al. (1997) highlighted that scale efficiencies can improve cost and profit efficiency in many situations. First, scale efficiency can increase profit as the unit average cost of production falls with increased size. In other words, it can improve cost efficiency by reducing costs per unit of output for a given set of output quantities and input prices. Second, it may increase profits through improvements in profit efficiency involving superior combinations of inputs and outputs resulting from large size. Also, De Young (1997) argued that moving closer to the best practice cost frontier is not the only way that firms can improve their cost inefficiencies. The reduction in per unit average cost can be achieved by growing larger to capture economies of scale through cost savings from spreading costs over large amounts of output.

As mentioned before, the firm may be described as efficient in terms of technical and allocative (i.e. economically efficient) but the scale of its operation may not be optimal. The firm can improve its cost and profit efficiency by producing at constant returns to scale. Figure 2.4 represents this by assuming that firms are using one input (X) to produce one output (Y). In the figure firms, A, B, and C are technically efficient because they are all operating on the production frontier. However, these three firms are technically efficient but the productivity of each is different due to the effects of scale. Firm A is operating in the increasing returns to scale, so it could become more efficient by increasing its operation to point B, where the proportional increase in the output is more than the proportional increase in the input /average cost, which means that the firm can produce more output with lower average cost. The firm at point C is operating in the decreasing returns to scale portion of the production frontier; it could become more productive by decreasing its scale of operation to point B. When this firm decreases its operation to point B, the proportional decrease in output will be less than the proportional decrease in the input/average cost, which means that the reduction in input (average cost) will be more than the reduction in output. Finally, the firm at point B is technically and scale efficient and is said to be operating at the most productive scale size. Visually, this is the point on the production frontier at which a ray from the origin is tangential to the production frontier (i.e. the proportional change in output is equal to the proportional change in the input/average cost because the angle of ray from the origin equals 45°).

Figure 2.4 Effects of Scale on Productivity



Source: Coelli et al. (2005, p.59)

Coelli et al. (2005) show that the scale economies for a single product firm can be measured as the ratio of technical efficiency of constant returns to scale to the technical efficiency of variable returns to scale. That is,

$$SE = TE_{CRS} / TE_{VRS} \tag{2.10}$$

where SE is scale economy, TE_{CRS} is technical efficiency under constant returns to scale, TE_{VRS} is technical efficiency under variable returns to scale.

Therefore when $SE \geq 1$, $SE = 1$, $SE \leq 1$, we are experiencing increasing, constant or decreasing returns to scale, respectively.

2.3.3 Scope Efficiency

Another source of cost saving a firm can realise is economies of scope (ES). Economies of scope arise if two or more products can be jointly produced at a lower cost than that incurred in their independent production (Molyneux et al., 1996). For instance, if we have two outputs y_1 and y_2 and their separate cost function are TC (y_1) and TC (y_2). If the joint cost of producing the two outputs is expressed by TC (y_1, y_2), then the economies of scope are presented if the cost of producing y_1, and y_2 jointly is less than producing y_1, and y_2, separately. Mathematically, an economy of scope is given by:

$$ES= [TC (y_1) + TC (y_2) - TC (y_1, y_2)] / TC (y_1, y_2) \tag{2.11}$$

If the value of equation 2.11 is greater than zero, economy of scope is present. Practically, the estimation of economy of scope in the banking industry is not an easy task. Unlike with manufacturing firms, banks' outputs cannot be measured by physical quantities. A bank is an entity engaged in the intermediation of services between lenders and depositors. Banks provide a wide array of services such as low-risk assets, credit and payment services and running of investment portfolios (Molyneux et al., 1996). Berger et al. (1993) mentioned that the major problem in estimating economy of scope in the banking industry is the lack of cost data for each output. In the context of this research, economy of scope will not be estimated for Jordanian banks because there is no information about cost for each bank's output. The total cost reported in banks' financial statements is related to all banks' output and it is difficult to separate cost for each output.

2.4 Measurement Approaches

As discussed earlier, frontier efficiency considers efficiency as relative rather than absolute and is concerned with comparing potential and actual performance (Lovell, 1993). Also, the previous section introduced Farrell's (1957) notion regarding measuring efficiency using a frontier approach. Since the true frontier is unknown, an empirical approximation is needed and this is called "best practice" (Fried et al., 2007). In estimating the efficiency frontier, accounting measures such as costs, inputs, outputs, revenue, profit, etc, are used to impute efficiency relative to the best practice based on the available data (Berger and Humphrey, 1997). Two approaches have been used in the literature for frontier estimation: parametric and nonparametric. These two approaches attempt to benchmark the relative performance of production units by estimating the best-practice frontier, but they differ in terms of the underlying assumptions. For example, Berger and Humphrey (1997) identify the following differences between the two approaches:

1. In terms of the functional form of the best-practice frontier, the parametric approach imposes a restrictive structure on the specification of the best practice frontier, whilst the nonparametric approach imposes relatively little structure.

2. In terms of the assumptions about random noise, the parametric approach assumes that a part of the deviation from the best practice frontier is due to (random error) and the remaining part of this deviation is due to managerial errors (inefficiency). However, the nonparametric approach assumes that deviation from the best practice frontier is wholly due to managerial errors (inefficiency). In other words, there is no random error in this approach.

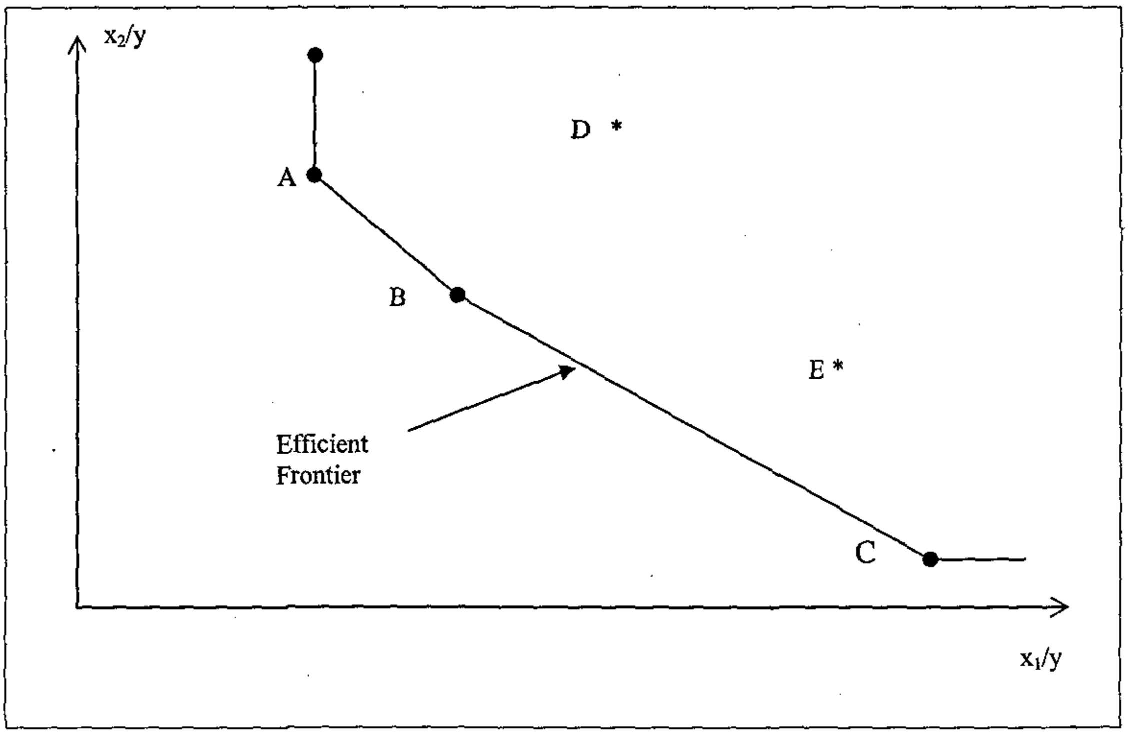
2.4.1 Nonparametric Frontier Approaches

The nonparametric approach pioneered by Charnes, Cooper and Rhodes (1978) is a linear programming technique which employs mathematical programming methods to construct production frontier to measure efficiency relative to that frontier. Thus, this approach depends on the envelopment of a data set by not allowing for random error (Lovell, 1993). Also, this approach assumes that all firms share a common technology and therefore face common production and cost frontiers: any variation in the firms' performance is therefore related to variations in their efficiencies and relative to these common frontiers. The nonparametric approach includes the data envelopment analysis (DEA) and the free disposal hull (FDH).

1. Data Envelopment Analysis Approach (DEA)

DEA is a nonparametric approach that uses a linear programming method to construct a piece-wise surface (or frontier) over the data. This approach was first proposed by Farrell (1957), and received wider attention 20 years later, when Charnes, Cooper and Rhodes (1978) reformulated Farrell's idea into a mathematical programming method able to deal with many inputs and outputs (Casu and Moleneux, 2003). Their idea was built on the construction of a piece-wise combination yielding a convex production possibility set that enveloped all firms in the sample. Figure 2.5 illustrates the idea of the DEA frontier, with five firms using two inputs to produce one output: the ratio of input (x_1/output y) for each firm is plotted on the horizontal axis and the ratio of input (x_2/output y) on the vertical axis. As shown in Figure 2.5, firms A, B and C define the efficient frontier because they are using the least input combinations to produce a fixed amount of outputs: the line connecting A, B and C represents the efficient frontier which is enveloping all the data. Firms D and E are considered inefficient.

Figure 2.5 Data Envelopment Analysis (DEA) Illustration



The efficiency of each firm within the sample is then calculated relative to the surface (i.e. frontier) (Coelli et al., 2005) and the calculated scores are defined as either the percentage reduction in the use of all inputs that can be achieved without a reduction in output or the percentage expansion in the output that can be achieved without expansion in inputs. DEA is nonparametric, in the sense that it simply constructs the frontier of observed input-output ratios through linear programming (Lovell, 1993). Under DEA, no explicit relationships exist between inputs and outputs: production, cost and profit functions are not estimated through the data (i.e. no algebraic relationships between inputs and outputs) (Ray, 2004). This approach shows how a particular firm operates in relation to other firms within the sample and so provides a benchmark for best practice within the industry. Accordingly, the DEA efficiency scores are not defined by an absolute term but are relative to other firms within the specific data set under consideration (Casu and Molyneux, 2003).

The original model of DEA, proposed by Charnes et al. (1978) is based on an assumption of constant returns to scale, although this assumption is not appropriate when firms exhibit economies or diseconomies of scale due to some factors such as market imperfection. Later developments to the DEA model considered alternative assumptions, such as variable returns to scale, introduced by Banker, Charnes and

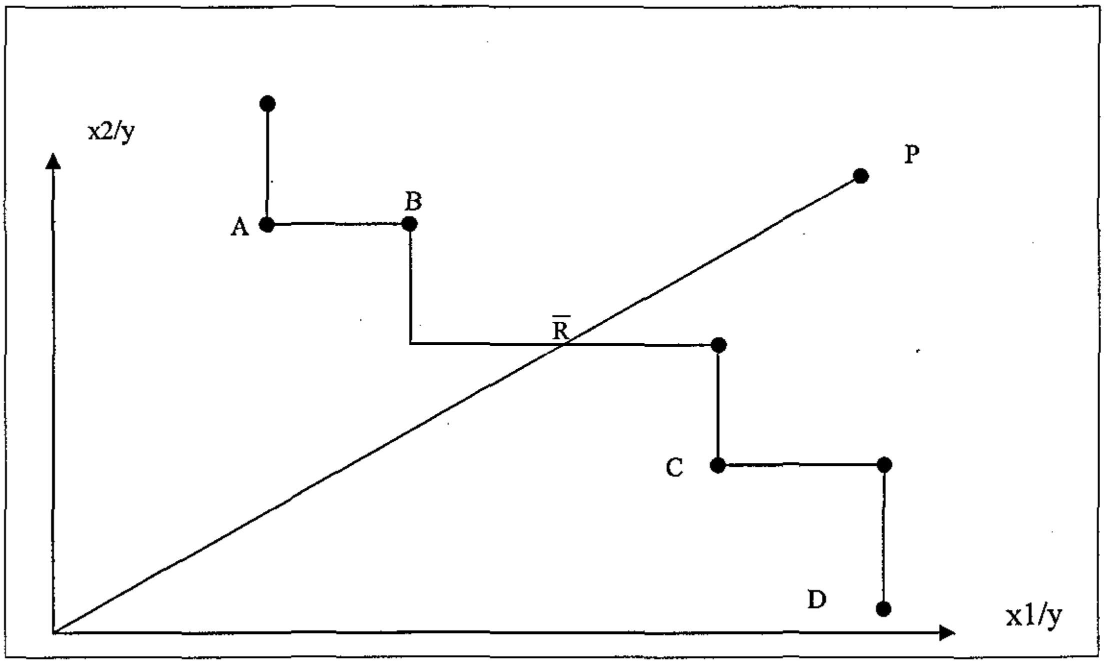
Cooper (1984). Finally, it is worth noting that the basic DEA model has been further extended to involve new concepts such as cost and profit efficiency, new cost and efficiency, non-discretionary variables, the treatment of slack and congestion efficiency, weights restrictions, efficiency and super efficiency[16]. Recent research regarding some extensions of the basic DEA model (such as cost efficiency, profit efficiency, new cost efficiency and new profit efficiency) will be used in this study and will be discussed in more detail in the methodology chapter.

2. Free Disposal Hull Approach

The Free Disposal Hull approach (FDH), developed by Deprins et al. (1984), is a special case of DEA. With FDH, the convexity of the production possibility set is abandoned and the set is composed only of DEA vertices and the FDH points interior to these vertices (Tulkens, 1993). Figure 2.6 illustrates the concept of FDH. Here, the efficient frontier is constructed from the actual observed measurements. Points such as $\overline{\mathrm{R}}$, for example, are not allowed because they are derived and not an actually observed performance. The point P in Figure 2.6 represents an inefficient firm and this firm should be compared with actual observations such as B or C where, under DEA, point P may be compared with the derived (hypothetical) point $\overline{\mathrm{R}}$. In other words, FDH is concerned with evaluation of a firm's efficiency with regard to the actual observed observations, while DEA allows measuring of the efficiency with regard to the frontier (i.e. projection point).

[16] For more details of the extension of the basic DEA model, see Cooper et al. (2007).

Figure 2.6 Free Disposal Hull (FDH) Illustration



The main drawback of this approach is that it can not be used to measure cost and profit efficiency and is used to measure just technical efficiency (Cooper et al., 2007).

2.4.2 Parametric Frontier Approaches

The parametric approach is an econometric technique that has been used in many studies to estimate a bank's (firm's) cost and profit efficiency. This approach requires the selection of economic concepts (i.e. profit function or cost function), a pre-specified functional form for the relationship between inputs and an output (e.g. translog functional form) and a distribution assumption for the error term of the estimated frontier (Bauer et al., 1998). The parametric approach consists of deterministic and stochastic frontiers.

1. Deterministic Frontier Models

The earliest models within the parametric frontier are usually referred to as deterministic frontiers because these models specify a one-sided error term (i.e. only representing the inefficiency component and did not allow random error-term (Kuenzle, 2005). The deterministic frontiers are based on Ordinary Least Squares (OLS) estimation and include Corrected Ordinary Least Squares (COLS) and Modified

Ordinary Least Square (MOLS). Deterministic frontier models are estimated by OLS and the residual (i.e. error term) of the OLS is used to estimate the inefficiency. In the case of a cost frontier, the model can be written as:

$$\ln TC_i = f\,(w_{ni}, y_{ki}, \beta_i) + \ln \varepsilon_i \tag{2.12}$$

where, $\ln TC_i$ is the logarithm of costs of the i-th firm, w_{ni} is the vector of prices of variable inputs of the i-th firm, y_{ki} is the vector of output levels of the i-th firm, βi represents the set of parameters to be estimated and ε_i is the error term representing the bank's cost/profit inefficiency, assumed to be non-negative and greater than zero. The value of the error term (ε_i) in equation 2.12 indicates the level of inefficiency: if ε_i is equal to zero, there is no inefficiency; if ε_i is more than zero, inefficiency is present. This model assumes that the error term is non-negative and being a one-sided error term represents the inefficiency component. As mentioned earlier, the estimation of production/cost/profit functions, using OLS as a performance measure, is not consistent with the theoretical notion of the optimisation process: the focus has instead turned to enveloping the data through the use of a cost frontier. Winsten (1957), in his discussion of Farrell's original paper, suggested that equation 2.12 could be estimated in such a way that it is consistent with the notion of the optimisation process (Kumbhakar and Lovell, 2000). Winsten (1957) suggested that equation 2.12 should be estimated by OLS and shifting the intercept down (in the case of the cost frontier[17]) by the highest residuals (i.e. error), in order to ensure that the estimated frontier bounds the data from the bottom (in the case of cost frontier[18]). Shifting the intercept down by the highest residuals makes sure that the firm with the lowest cost is used as a benchmark to evaluate other firms. This model is called Corrected OLS (COLS).

Afriat (1972) and Richmond (1974) showed that COLS is vulnerable to outliers because the intercept is shifted by the highest residuals. They proposed a slightly different version of COLS, known as Modified Ordinary Least Square (MOLS). They suggested that equation 2.12 could be estimated by OLS, under the assumption that the residuals (i.e. ε_i) follow an explicit one-sided distribution, such as half-normal (Kumbhakar and Lovell, 2000). The assumed shape of the distribution motivated by the larger degree of inefficiency is less probable than smaller degrees of inefficiency and, as in the COLS

[17] In the case of the production and profit frontier, the intercept is shifted up.

[18] In the case of production and profit frontiers, the estimated frontier bounds the data from the top.

model, the OLS intercept is shifted downwards but by means of the assumed one-sided distribution (Kumbhakar and Lovell, 2000). However, there is no guarantee that COLS shifts the intercept down by enough to ensure that all firms are bounded from the bottom (Lovell, 1993). However, the main drawback of frontiers estimated by COLS and MOLS is that they do not take into account the random error and still assume that all deviation from the frontier is caused by inefficiency (Coelli et al., 2005).

2. Stochastic Frontier Models

The second class of frontier models is called stochastic frontier models. These models allow for a composite error term, which consist of an inefficiency component and random noise (random shocks outside the control of the producer) (Berger and Humphrey, 1997). There are three classes of stochastic frontiers models: stochastic frontier approach (SFA), the thick frontier approach (TFA) and the distributional free approach (DFA).

a- Stochastic Frontier Approach (SFA)

To overcome the drawback of the deterministic frontier, Aigner, Lovel and Schmidt (1977) and Meeusen and Van den Broeck (1977) independently proposed the first stochastic frontier model. This model allows for the error term to consist of an inefficiency component and a random error (Berger and Humphrey, 1997). The stochastic frontier for cost minimisation can be given as:

$$\ln TC_i = f\,(w_{ni}, y_{ki}, \beta i) + \ln \varepsilon_i \quad . \tag{2.13}$$

The error term ε_i in equation 2.13 now is equal to

$$v_i + u_i \text{ for cost frontier} \tag{2.14}$$

$$v_i - u_i \text{ for profit frontier} \tag{2.15}$$

v_i is a random error component that permits random variation of the frontier across banks and captures the effects of measurement errors, other statistical noise and random shocks outside the bank's control. This error is assumed to be independently and identically distributed normal random variables with zero mean and variance σ^2. u_i, is a non-negative and one-sided error component. That follows a half-normal distribution capturing the effects of inefficiency relative to the stochastic frontier. The SFA specifies a functional form for the cost and profit function and permits a composed error term (ε_i). The inefficiency (u_i) is measured by separating the inefficiency component from the overall error term (ε_i) (Cummins and Zi, 1998) and the estimated inefficiency for any firm is taken as the conditional mean or mode of the distribution of the inefficiency term, given the residual, which is an estimate of the composed error (Berger and Humphrey, 1997; Bauer et al., 1998). The SFA can be employed within a single cross-section or panel data[19].

b. Thick Frontier Approach (TFA).

The SFA requires restrictive assumptions about the error term (i.e. the distribution of u_i and v_i) to estimate cost and profit efficiency. Berger and Humphrey (1991, 1992) developed the thick frontier approach (TFA) in order to avoid the restrictive assumptions about the error term and this can be employed within a single cross-section or panel data (Kumbhakar and Lovell, 2000). As with SFA, TFA requires a functional form for the cost and profit function and involves dividing the firms in the sample into four quartiles, based on total cost per unit of assets[20] (Mester, 1996). The firms are then placed in the top and bottom quartiles according to their average costs (i.e. total costs to total assets). Firms in the bottom quartile are presumed to be relatively cost efficient as a group and they define a thick frontier. Firms in the top quartile are presumed to be cost inefficient in relation to the thick frontier (Kumbhakar and Lovell, 2000). The cost functions for firms in the top and bottom quartiles are estimated and the deviation in predicted costs between the highest and lowest quartiles represents inefficiencies (Berger and Humphrey, 1997; Bauer et al., 1998) and the variation of the residuals within each quartile is assumed to reflect the random error. Thus the error term (ε) in the estimated functions is assumed to represent only the random error. The main shortcoming of the TFA is that it does not provide exact point estimates of efficiency for each firm. Rather, TFA provides an estimate of the general level of overall efficiency through measuring the difference between the best and worst quartiles. Kumbhakar and Lovell (2000) argued that the TFA is likely to be useless to management and of limited value to policy-makers because it provides only one

[19] Cross- section data are observations on each producer for one period, whereas panel data usually contains more repeated observations for each producer over a period of time.
[20] This is done by dividing total costs for each bank by its total assets.

efficiency score for a group of banks (i.e. firms in the top quartile) and ignores the data of banks in the second and third quartiles. Due to this shortcoming, the TFA is rarely used in empirical studies.

c. Distribution Free Approach (DFA)

The DFA was introduced by Berger in 1993 and uses only panel data for estimation (i.e. repeated observation of each bank over a period of time) (Kumbhaker and Lovell, 2000). As with SFA and TFA, the DFA specifies a functional form for the cost and profit function. However, the DFA does not impose a specific shape on the distribution of inefficiency (SFA does). Berger (1993) assumes that there is a core efficiency or average efficiency (u_i) for each firm that is constant over time, while the random error (v_i) tends to average out over time (Bauer et al., 1998). In other words, Berger (1993) assumes that inefficient firms remain inefficient over time and the effects of the random error tend to equal zero as the time increases. To estimate the cost or profit inefficiency (u_i) for firms, many years of observations should be available[21]. The DFA is estimated by the following equation:

$$\ln TC_{it} = f\,(w_{nit}, y_{kit}, \beta i\,) + \ln \varepsilon_{it} \tag{2.16}$$

where $\ln TC_{it}$ is the logarithm of costs of i-th firm at time t, w_{nit} is the vector of prices of variable inputs of the i-th firm at time t, y_{nit} is the vector of output levels of the i-th firm at time t, βi represents the set of parameters to be estimated and ε_{it} is the error term of the i-th firm at time t. DFA estimates a cost/profit function for each period for all firms and an average of residuals is calculated for each firm over all periods. This estimated average is transformed into a measure of inefficiency by comparing the average of residuals for each bank with the smallest residuals within the sample (Allen and Rai, 1996). The main disadvantage of DFA is the requirement that cost efficiency is time invariant[22]; this assumption becomes less tenable as time increases, as it is possible that some firms were inefficient and became efficient as time increased (Kumbhaker and Lovell, 2000).

[21] Berger (1993) suggests that five years' observation is typically appropriate for using DFA.
[22] This model assumes that the structure of production technology is constant through time; that is, no allowance is made for technical change (Kumbhakar and Lovell, 2000)

Because of drawbacks of TFA and DFA, this research, the SFA will be used to estimate cost and profit efficiency for Jordanian banks and the SFA methodology will be discussed in more detail in Chapter 5.

2.4.3 Is there a Best Frontier Approach?

As discussed above, there are two approaches for measuring firms' (banks') efficiency: parametric and nonparametric. Despite the extensive use of both of these approaches, there is no agreement between researchers regarding which approach produces a better estimate of efficiency scores (Bauer et al., 1998). This disagreement can be viewed from two sides: empirical and theoretical. On the empirical side, it is not possible to determine which of the two major approaches fares better than the other because the true level of the efficiency of firms is unknown (Berger and Humphrey, 1997). On the theoretical side, it is difficult to reach an agreement, as the two approaches have their relative advantages and disadvantages.

The main advantages of the parametric approach over nonparametric approach are (i) the former takes into accounts the random error and (ii) can be used for conventional hypotheses testing (Coelli et al., 2005). Some disadvantages of the parametric approach include the need to specify a functional form (i.e. the algebraic relationship between the dependent variable and the independent variables, such as translog functional form) for the cost or profit function and the need to determine a distributional form for the error term. The restrictions imposed on the functional form of the estimated frontiers could lead to misspecification problems and, consequently, distort the measured efficiency scores (e.g. overestimated or underestimated). Thus, the nonparametric approach is preferable because this does not require an assumption of a functional form relating inputs to outputs (Ramanathan, 2003). Another disadvantage of the parametric approach, SFA, is the arbitrary assumption regarding the probability of distribution of the error term (e.g. half-normal distribution) (Berger and Mester, 1997). Regarding the measured efficiency score affected by the chosen distribution for the error term, Coelli et al. (2005) pointed out that different assumptions about the error term yield a different efficiency score[23].

[23] Greene (1990) estimated a parametric approach (SFA) for 123 US electric utilities, using four distributions (i.e. half-normal, gamma, exponential and truncated normal distribution). He reported

The main disadvantages of the nonparametric approaches are that these are deterministic, where measurement error and statistical noise are assumed to be non-existent. This assumption about the non-existence of the measurement error may influence the shape and position of the frontier (Coelli et al., 2005), distorting the measured efficiency scores[24] (for more details about the limitations of nonparametric approaches, especially DEA, see Coelli,et al.,2005 and Ramanathan, 2003). Berger and Mester (1997) also reported that studies involving U.S banks that used nonparametric apporaches reported lower efficiency means, on average, than those using parametric techniques.

Given the advantages and disadvantages of parametric and nonparametric approaches, Bauer et al. (1998) argued that it is not necessary to have an agreement on which is the single best approach that can be used to measure efficiency levels. Instead, it is more important that the efficiency estimates derived from different approaches should be consistent in the following ways:

1. The efficiency scores obtained from different approaches should have comparable means, standard deviations and other distributional properties.
2. The different approaches should rank the firms according to their level of efficiency in the same order.
3. The different approaches should identify, in most cases, the same firm as best practice and as worst practice.
4. The efficiency scores generated for firms should be consistent with the structure of the market in which they operate (e.g. it is expected that firms operating within a more competitive market will have higher efficiency scores).
5. The measured efficiency scores should be reasonably consistent with non-frontier performance indicators, such as ratio analysis.
6. The efficiency scores should be reasonably stable over time.

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sample mean efficiencies of 0.87(half-normal), 0.90 (exponential), 0.89 (truncated normal) and 0.89 (gamma)

[24] Recent developments in bootstrapping techniques are used in DEA to correct efficiency estimates for bias and to assess the uncertainty which results from the non-existence of measurement error. The bootstrap is a way to analyse the sensitivity of the efficiency score relative to the sample variation of the estimated frontier (for more detail about bootstrapping in DEA analysis, see Simar and Wilson (2000)). An example of a study using bootstrapping in DEA is by Casu and Molyneux (2003).

2.5 Functional Forms

As indicated earlier, the use of the parametric approach requires specifying the functional form for cost and profit efficiency. The cost and profit function expresses a single dependent variable as a function of one or more explanatory (independent) variables (Coelli et al., 2005), with the cost function expressing cost as a function of input prices and outputs and the profit function as the function of input prices and output prices.

The first step in estimating the relationship between the dependent and independent variables is to specify the functional form. Lau (1986), Chambers (1988) and Coelli et al. (2005) have proposed some criteria for the selection of an approximate algebraic forms that are consistent with particular economic relationships (e.g. cost function, profit function). These are:

1. Theoretically consistent: The algebraic functional form chosen should be capable of reflecting the properties of the cost and the profit function mentioned earlier.
2. Flexibility: A functional form should have enough parameters to provide second-order approximation. A functional form is said to be second order-flexible if it has enough parameters to provide a second order differential (derivative) approximation. The second order approximation is very important for applied production analysis since it is a measure for scale economy and the change in technology over a time (Chamber, 1988; Coelli et al., 2005).

In the literature for estimating cost and profit functions there are many functional forms employed: the most common are the Cobb-Douglas functional form, the translog functional form and the Fourier flexible form.

2.5.1 Cobb-Douglas Functional Form

Arguably, the best known empirical function was introduced by Cobb-Douglas in 1928, and takes the following form:

$$TC_i = \alpha_0 \prod_{k=1}^{K} y_k^{\delta_k} \prod_{n=1}^{N} w_n^{\beta_n}, \tag{2.18}$$

or taking the logarithm, it is written as:

$$\ln TC_i = \ln\alpha_0 + \sum_{n=1}^{N}\beta_n \ln w_{ni} + \sum_{k=1}^{K}\delta_k \ln y_{ki}$$

(2.19)

where $\ln TC_i$ is the logarithm of costs of the i-th firm, w_{ni} is the vector prices of variable inputs of the i-th firm, y_{ki} is the vector of output levels of the i-th firm and α_0, β_n and δ_k are parameters to be estimated.

The Cobb-Douglas cost function is only homogeneous of degree one in input prices (see property 4 in section 2.2), if $\sum_{n=1}^{N}\beta_n = 1$. This implies the proportionate increase input prices has resulted in the same proportionate increase in the cost. The linear homogeneity restriction can by implemented by dividing costs and prices by one price. The main shortcoming of the Cobb-Douglas function is that it is, at best, a first-order approximation (Chambers, 1988) and thus exhibits a constant value for economies of scale (i.e. constant, decreasing or increasing) (Coelli et al., 2005). The total cost (TC) elasticities under the Cobb-Douglas function do not vary with the variation of outputs[25]. Moreover, this function implicitly assumes that technological change is constant[26]. Because of the shortcomings of the Cobb-Douglas function, it is rarely used in relation to the estimation of cost or profit frontiers in the literature (Coelli et al., 2005).

2.5.2 Translog Cost Function

A generalisation of the Cobb-Douglas functional form is the so-called translog form, introduced by Christensen et al. (1973). The translog functional form can be written as:

$$\begin{aligned} \ln TC_i = {} & \alpha_0 + \sum_{n=1}^{N}\beta_n \ln w_{ni} + \sum_{k=1}^{K}\delta_k \ln y_{ki} + \frac{1}{2}\left[\sum_{n=1}^{N}\sum_{j=1}^{J}\beta_{nj}\ln w_{ni}\ln w_{ji}\right] \\ & + \frac{1}{2}\left[\sum_{k=1}^{K}\sum_{m=1}^{M}\delta_{km}\ln y_{ki}\ln y_{mi}\right] + \sum_{n=1}^{N}\sum_{k=1}^{K}\eta_{nk}\ln w_{ni}\ln y_{ki} \end{aligned} \qquad (2.20)$$

where $\alpha_0, \beta_n, \delta_k, \beta_{nj}, \delta_{km}, \eta_{nk}$ are parameters to be estimated.

[25] Elasticities of total cost (TC) with regard to outputs can be shown as the first derivative of TC with regard to output in equation 2.19 as: $\frac{\partial \ln TC}{\partial \ln y_k} = \delta_i + \sum_{n=1}^{N}\beta_n \ln w_i$. *Thus for any change in outputs the total cost* will be change by a constant number (i.e. δ_i).

[26] See Coelli et al. (2005, p. 213) for an example.

Since the duality theorem requires that the cost function is linearly homogeneous in input prices and continuity requires that the second order parameters are symmetric, the following restrictions apply to the estimated parameters of the cost function:

$$\sum_{n=1}^{N}\beta_n = 1, \sum_{n=1}^{N}\beta_{nj} = 0 \text{ and } \sum_{n=1}^{N}\eta_{nk} = 0$$

As with the Cobb-Douglas cost function, the linear homogeneity restrictions are implemented by either dividing the costs and the prices by one price or putting the restrictions directly on the function (Coelli et al., 2005). The translog functional form is more flexible than the Cobb-Douglas, as it provides second order approximation and allows the economies of scale to vary with the output level (Coelli et al., 2005). Moreover, the translog function allows technological change to increase or decrease with time (Coelli et al., 2005). The translog cost functional form is widely used in bank' efficiency literature, yet it is subject to certain limitations. McAllister and McManus (1993) and Mitchell and Onvural (1996) demonstrated how it does not fit well with data far from the mean,[27] in terms of output size. Also, the translog functional form is called *the locally flexible form, which means that the cost function does not fit all the data to the greatest possible extent* (Sauer et al., 2006). Despite its limitations, the translog function is still the most used in the applied production analysis because of its flexibility and its forecasting ability to generate efficiency scores better than other functional forms (Altunbas and Chakaravarty, 2001).

2.5.3 Fourier Flexible Form

This is an extension of the translog functional form proposed by Gallant (1981, 1982) to overcome the problems associated with the locally flexible translog functional form. The Fourier form consists of two parts: the first is the usual translog function and the second is a Fourier expansion: this is a linear combination of sin and cosine of the variables used to estimate the translog function. Spong et al. (1995) argued that the Fourier flexible form is superior to the translog functional form, as it provides better approximates for the underlying cost function across a broad range of outputs. The main

[27]Translog is approximated from Cobb-Douglas functional form by using Taylor series expansion method (Kuenzle, 2005). The Taylor series is mathematical technique used to expand any function in a point. In translog function, the expansion point is the mean of the variables to be expanded (i.e. y, w, TC). Translog functional form is called locally flexible form because it does not give exact estimation for all *points in estimated function*. .

problem with the Fourier flexible form is that there are many more parameters to estimate and this may give rise to multi-collinearity problems and requires large numbers of observations to estimate cost and profit efficiency[28] (Coelli et al., 2005).

2.6 Conclusion

This chapter presents a theoretical overview of the relationship between economic theory and the internal efficiency of the firm. It shows how the different market structures in which the firm is operating can affect its internal efficiency. Under perfect competitive theory, the firm should be operated efficiently, otherwise the market will penalise the inefficient firm by driving it out of the market. However, if the market structure is imperfect (monopoly, monopolistic competition or oligopoly) the firms can exercise market power by setting their prices above the competition level. This will induce the firms not to operate efficiently by not working hard to keep costs under control. The different market structures which are stemming from the neoclassical theory seek to explain how the market works rather than to understand the internal function of the firm. The neoclassical theory is challenged by alternative theories (e.g. X-efficiency, managerial discretion, principal- agent and behaviour theories) which aimed to explain why some firms are not operating efficiently by not seeking profit maximisation or cost minimisation behaviours.

Moreover, this chapter explained the definition of efficiency which is concerned with the relationship between inputs and outputs levels and some desirable objectives such as cost minimisation or profit maximisation. This chapter also showed the difference between absolute efficiency and relative efficiency. Also, this chapter showed different kinds of efficiency according to the economic theory and the conceptual framework underpinning the relative efficiency measurement. It showed that the relative productive efficiency has two orientations: input and output orientation, also that the overall productive efficiency can be decomposed into technical and allocative efficiency. The combinations of technical and allocative efficiency provide a measure for economic efficiency or overall efficiency. Economic efficiency is a broader concept than technical efficiency, since it is consistent with economic theory to reach desirable objectives such as cost minimisation or profit maximisation.

[28] For more details about functional forms, see Champer (1988).

Finally, this chapter showed that the relative efficiency of a firm can be measured by using parametric or nonparametric approaches to formulate a best practice frontier. The parametric approach uses econometrics and requires the selection of economic concepts (i.e. cost or profit function), a functional form for the relationship between inputs and outputs (e.g. translog function) and a distribution assumption for the error term of the estimated frontier. The nonparametric approach uses mathematical programming; no cost or profit function is estimated from the data and no error term is produced and any deviation from the frontier is considered as inefficiency. Despite the extensive use of both of these approaches within banking research to measure efficiency levels, there is no agreement between researchers regarding which approach can produce a better estimate of efficiency scores (Bauer et al., 1998).

The next chapter will introduce the importance of frontier analysis within the banking industry, as tool to benchmark banks' performance against the best practice performer and as a tool to investigate the impact of policy makers' procedures on banks' performance. Also, the next chapter will show how frontier analysis can be used to test many conceptual issues (i.e. deregulation, ownership structure) by reviewing different studies in the banking industry.

Chapter 3 Efficiency in the Banking Industry: Empirical Evidence

3.1 Introduction

The previous chapter introduced frontier efficiency as a tool to measure efficiency levels within the context of economic theory. Moreover, the previous chapter showed the different approaches that may be used to measure the main types of efficiency. This chapter continues to show the importance of frontier analysis within the banking industry as a tool to benchmark banks' performance against the best practice performer and as a tool to investigate the impact of policy makers' procedures on banks' performance. Moreover, this chapter highlights related theories regarding the regulation and deregulation of the banking sector and their consequences on efficiency levels. Also, this chapter reviews different empirical studies of the efficiency of banks that aimed to test many conceptual issues such as the impact of deregulation, ownership structure and bank characteristics on the level of bank efficiency.

Section 3.2 introduces the role of banks in economic development and growth and highlights the importance of the existence of an efficient banking sector capable of mobilising its financial resources and directing them towards activities with higher expected rates of return. Section 3.3 introduces related theories to examine the rationale for regulation and deregulation of the banking system and the effect of that on the efficiency of banks. Section 3.4 emphases the importance of frontier analysis techniques within the banking industry, as these provide a superior method over traditional techniques (e.g. ratio analysis) in measuring performance. Section 3.5 outlines the different approaches used to specify inputs and outputs that measure the efficiency of banks, using different frontier approaches and section 3.6 reviews empirical studies on the efficiency of banks.

3.2 Role of Banks in Economic Development and Growth

Over the past few decades, the relationship between financial institutions and economic growth has received attention in economic literature. It is argued that the operations of financial institutions, especially banks, are crucial for economic activity and growth. For example, Hick (1969) argued that the financial system in Europe played a critical role in launching industrialisation by facilitating the mobilisation of capital for immense work. Moreover, seminal work by Schumpeter (1912, 1939) showed that financial institutions (e.g. banks) play an important role in promoting economic growth by redirecting funds towards innovative projects. The emergence of financial institutions (e.g. banks) can be attributed to the existence of market frictions in the form of information asymmetries and transaction costs[29] (Schumpeter, 1912; Hicks, 1969; Levine, 1997). The reducing of information and transaction costs leads banks to facilitate the allocation of resources in an uncertain environment (Merton and Bodie, 1995). Thus the existence of a financial system is important in order to intermediate between saving and investing economic units. The main role of a financial system is pooling savings from customers and re-directing them to diversified investment projects (Greenwood and Jovanovic, 1990). Levine, (1997, 2004) summarises the main functions of banks as:

- facilitating the trading, hedging, diversifying, and pooling of risk;
- allocating resources;
- monitoring managers and exerting corporate control;
- mobilising savings ;
- and facilitating the exchange of good and services.

Levine (1997) argued that the functions of banks affect economic growth through capital accumulation: functions performed by banks affect steady-state growth by influencing the rate of capital accumulation, either by altering the saving rate or by reallocating savings among different capital-producing technologies. The funds in a banking system flow from those who have a surplus to those who have a shortage, and financing through financial intermediaries (i.e. banks) is an effective solution to adverse selection[30] and moral hazard[31] problems that exist between lenders and borrowers (Duisenberg, 2001). To facilitate trading, banks have developed expertise and risk

[29] These costs include the cost of acquiring information, enforcing contracts and exchanging goods and financial claims (Levine, 1997).

[30] It refers to a market process in which bad results occur due to information asymmetries between lenders and borrowers. For example, the lender may lend money to a bad customer because he/she does not have information about him/her.

[31] The risk that a party to a transaction has not entered into the contract in good faith has provided misleading information about its assets, liabilities or credit capacity (Boyd et al., 1998).

management teams to distinguish between good and bad borrowers and to select the most viable projects in which to invest. Bank finance plays a key role for many companies in need of funds and thus helps to ensure a well-balanced growth process (Duisenberg, 2001). Miwa and Ramseyer (2000) argue that banks promote growth through their superior monitoring and screening capabilities. Here, banks reduce information asymmetries and the attendant moral hazard and adverse selection problem and improve the allocation of credit. Herring and Santomero (2000) suggest how a well-functioning banking system makes a critical contribution to economic performance by facilitating transactions, mobilising savings and allocating capital across time and space. Financial institutions provide payment services and a variety of financial products that enable the corporate sector and households to cope with economic uncertainties by hedging, pooling, sharing and pricing risks. Levine et al. (2000) point out that banks emerge to lower the costs of researching potential investments, exerting corporate control, managing risk, mobilising savings and conducting exchanges. In providing these services to the economy, banks influence savings and allocation decisions in ways that may alter long-term growth rates. Levine's (1997) empirical research in many countries reported that banking functions are positively related to economic growth. Overall, the banking system has major roles to play in the economy. In particular, banks help direct financial resources to their most efficient use, thus enhancing economic growth.

3.3 Deregulation and Bank Efficiency

Given the important contribution the banking sector makes to economic growth, an efficient banking system would mobilise its financial resources and direct them towards activities with higher expected rate of returns for a given level of risk (Das and Ghosh, 2006). Analysts of economic growth have long discussed the proper role of the government in promoting economic growth (e.g. McKinnon, 1973; Shaw, 1973; Fry, 1975; Levine, 1997; Stiglitz, 1994) and there have been many arguments about whether the 'regulated' or 'market based' financial system performs better in promoting development. Most economists however, agree that each system has its own advantages and disadvantages. The market approach assumes that the market generally functions efficiently and so the government should not intervene to direct the financial system (see McKinnon, 1973; Shaw, 1973). In contrast, the regulated base assumes that government intervention should act to prevent market failure (Stiglitz, 1994; Fry, 1995). This section outlines the grounds and rationale for regulation of the banking system in general. It describes the consequences of the deregulation of the banking system on banks' efficiency and performance. It then considers the removing of restrictions on foreign banks' entry in the local banks and any consequences on local bank efficiency.

3.3.1 Rationale for Regulation

Regulation may be defined as various rules set by a government or its agencies, which aim to control the operations of firms (Griffiths and Wall, 2001). The purpose of regulation is the prevention of market failure, where 'market failure' is a general term that describes situations in which the allocation of goods and services by a market is unacceptable. As Stewart (1997) points out, there are four broad categories of market failure:

1. **Asymmetric** (or imperfect) **information**: The competitive model analysed earlier assumed that all firms and buyers have all the information they need for their decision. However, in reality, things are very different, with consumers in particular experiencing a lack of information. Government intervention could reduce the effects of a lack of information and improve customers' welfare[32] (Fry, 1995).
2. **Externalities**: Externality may be defined as a situation where the effect of production or consumption of goods and services imposes costs or benefits on a third party not reflected in the price charged for the goods and services being provided (Khemani, 1990).
3. **Public goods**: The term 'public good' is used to refer to goods that are non-excludable and non-rival: this means it is not possible to exclude individuals from the good's consumption. Non-rivalry and non-excludability may cause problems for the production of such goods by the market, especially when it is not possible to charge a price for some public goods. Regulation may be required if such goods or services are to be provided to all at low cost or no cost (Baumol and Blinder, 1982). An example of a public good within the banking

[32] Asymmetric information has recently been noted to be on the decline due to the Internet, which allows unknowledgeable users to collect relevant information regarding their interests.

industry is the information about the management and solvency of financial institutions (Fry, 1995).

4. **Monopoly**: As discussed earlier, under monopoly, resources are misallocated, due to the ability of the producer to set prices above competitive price levels. Regulation may be used to prevent the abuse of monopoly power (Griffiths and Wall, 2001).

Most governments in the world, especially in developing countries, subject their banks to certain requirements, restrictions and guidelines, in order to maintain the soundness[33] and integrity of their financial system. The banking industry in most economies is heavily regulated, because the failure of banks could have great effects on the whole economic system of a country (Kumbhakar and Sarkar, 2003). The failure of one individual bank could spread and become general through contagion risk[34], along with uncertainty about the condition of other banks.

The restrictions imposed by regulators on the scope and operations of banks, such as high reserve requirements, a ceiling on interest rates paid on deposits and for loans, entry barriers, heavy government-directed lending, product restrictions, limits on foreign exchange transactions and specific capital requirements, are implemented to ensure that the financial system is sound and safe and to protect individual investors and depositors from the consequences of bank failure (Fry, 1995). The argument behind restricting banking activity is based on many factors: not least, the prevention of market failure and the protection of the consumer from the consequences of market failure (Stiglitz, 1994). Such regulation also prevents the conflicts of interest that may arise if banks are allowed to operate in a non-restricted way regarding securities' underwriting, insurance underwriting and real estate investment. Regulation is arguably therefore required to prevent the abuse of monopoly power and excessive pricing (Barth et al., 2004; Boyd et al., 1998; John et al., 1994) and protect financial markets and institutions

[33] A sound financial system can be viewed as one that is operating safely, without serious problems that could threaten its stability. The soundness of a financial system can be enhanced by effective market discipline, effective bank supervision and effective risk management from banks (for details, see Basel, 1998).

[34] Contagion risk regards the financial difficulties at one or more bank(s) spilling over to a large number of other banks or the financial system as a whole.

from shocks that might cause systematic risk[35] (Herring and Santomero, 2000). Regulation also minimises the likelihood of an economic downturn resulting from a financial crisis (Stiglitz, 1994).

3.3.2 Deregulation vs. Regulation: Benefits and Costs

The co-ordination of economic activity across the various agents of the economy is the central role of an economic system (McKinnon, 1973). The banking system in many developing countries experiences poor performance and low levels of efficiency (Kumbhakar and Sarkar, 2003) and heavy governmental intervention in the banking system and the restrictions imposed on the scope and operation of banking activities are seen as main factors that cause banks' poor performance and low efficiency levels (Kumbhakar and Sarkar, 2003). Also, the rapid changes in banking technology, such as Internet banking and telephone banking, have enabled large institutions to expand their activities away from narrow national boundaries: this can put banks in developing countries under greater pressure and they must work efficiently and effectively within their market to be able to survive these new challenges (Molyneux et al., 1996). In the early 1980s, many developing countries undertook a substantial liberalisation programme of the banking system through deregulation in order to make them more efficient (Kumbhakar and Sarkar, 2003) and to help them to cope with these new challenges. The main objectives behind such deregulation are to improve competition in the market and to increase both efficiency and the soundness of the banking system. Financial deregulation in developing countries could and have included the following measures, as summarised by Fry (1995):

1. Removing interest rate ceilings on deposit and loans;
2. Removing restrictions on foreign exchange transactions;
3. Removing/alleviating restrictions on banks' portfolios;
4. Relaxation of foreign banks' entry to the local market;
5. Removing or decreasing the reserve requirements;
6. Promoting branch expansion;
7. Removing government intervention in banks' lending decisions;
8. Removing ceiling on amounts of credit;

[35] Systematic risk is defined as the risks of an anticipated event that cannot be diversified away because it is a risk of movement in the overall market or relevant market segment. The systematic risk could cause damage to the whole financial system.

9. Privatisation of state-owned banks.

To a large extent, such a liberalisation of the financial system in developing countries was influenced by the views of McKinnon (1973) and Shaw (1973), sometimes referred to as the 'McKinnon-Shaw Hypothesis'.

McKinnon and Shaw challenged the policy of financial repression characterised by imposed ceilings on interest rates, high reserve requirements and government-directed lending. Their view focused on the negative impact of ceilings on deposits and loan rates on the stability and growth of the financial system and they argued that this "financial repression" could contribute to the decline of financial growth. If interest rate ceilings lead to low or negative real interest rates, this in turn will lead to reduced savings and a lower amount of loan funds intermediated through the financial system (Andersen and Tarp, 2003). McKinnon and Shaw analysed the impact of a reduction of financial repression on the domestic financial system within developing countries and they found that this exercised a positive effect on the growth of interest rates towards their competitive market equilibrium (mainly by allowing market forces to determine real interest rates). According to the McKinnon-Shaw hypothesis, the removal of ceilings on interest rates increases savings and encourages the financial system to be more efficient in the allocation of resources. Liberalised financial systems direct scarce economic resources to the most efficient use and this impact positively on the growth of the national economy.

The McKinnon-Shaw view is based on the macro dimension of the impact of reducing financial repression on the financial system. Another macro dimension that could be achieved by less regulation is an increase in competition in the banking industry through the removal of entry barriers and the removal of interest rate ceilings. Increased competition within the industry may increase the levels of efficiency amongst banks and thus the public will benefit in terms of cost and the availability of banking services (Molyneux et al., 1996). Similarly, Winston (1998) argues that firms operating in a deregulated industry operate more efficiently than those in a heavily regulated industry. He states that regulations limit competition between firms and that this lack of competition causes an industry to accumulate substantial managerial slack. Winston presents empirical evidence from many deregulated industries in the USA, showing that such industries have become more efficient after deregulation and the level of competition between firms increased. This intensified competition causes firms to operate more efficiently. For example, Winston (1998) reported that the operating costs of deregulated banks in the US have decreased by 8 per cent and returns in equity have improved.

At the other end of the spectrum, there are many views that concentrate on the micro dimension of the impact of deregulation on the financial system. Reger et al. (1992) argue that the field of strategic management assumes that managers match their firms' strategies to the characteristics of their environment and firms obtaining superior matches (e.g. choosing the best product mix) will enjoy superior competitive positions and high levels of performance. However, Mahoon and Murray (1981) argued that government regulation and deregulation are important factors that can affect the strategic choice of managers which, in turn, could affect financial performance and risk. Therefore, within a strict regulatory environment, a bank's choices will be limited and this will have a direct and indirect effect on the bank's performance through a restriction of strategic options. Therefore, deregulation (of the financial system) could reap benefits, such as producing a variety of products and services that may enhance profitability and efficiency by the optimal use of resources in producing bank outputs (Merrick and Saunders, 1985) and the creation of a competitive banking system while the opportunity exists to produce the optimum quantity of money and resources (Friedman, 1969). However, deregulation may be accompanied with consequences that may threaten the safety and soundness of the financial system, such as banks' being more likely to invest in risky products (Merrick and Saunders 1985). Gruben and McComb (1997) reported how the portfolio of banks in Mexico became more risky after deregulation because they could not evaluate the risks associated with loans and higher real interest rates.

Fry (1995, 1997) identified many pre-requisites that could lead to successful financial liberalisation:

- Adequate prudential regulation, needed to enhance the stability of a financial system and limit excessive risk-taking by banks;
- Successful monetary policy, resulting in a reasonable degree of price stability;
- Authorities where necessary, reducing taxes on the banking system.

3.3.3 *Entry of Foreign Banks to Local Markets*

An important part of deregulation is to remove restrictions on the entry of foreign firms into the domestic banking market. This may take two forms: (1) regulations allowing the entry of foreign-controlled banks to the local market, and (2) regulations providing incentives for foreign ownership to invest in the common stock of local banks (Unite and Sullivan, 2003). Allowing foreign banks to enter a domestic market and allowing foreign investors to hold common stocks in domestic banks may increase the competitiveness of the local banking market, thus enhancing levels of efficiency (Unite and Sullivan, 2003).

Levine (1996) and Goldberg (2003) identified many benefits and effects associated with allowing foreign banks' entry to the domestic market:

1. Improved allocation efficiency: When foreign banks are allowed entry to industries with high entry barriers, they may help decrease monopoly and foster competition within the local market;
2. Transferred and diffused advanced technology: Foreign banks coming from more industrialised countries will introduce new technologies to the local market, which may help local banks to improve efficiency in their operations. Allowing foreign banks entry to the local market could also help in promoting managerial skills and transferring new knowledge to the domestic market. These skills and knowledge may take the form of marketing and managing skills, export contact and a more co-ordinated relationship between bank management and customers.

There may however also be costs in opening the local market to foreign banks. Stiglitz (1994) argued that domestic banks may incur extra costs, as they have to compete with larger and stronger international banks with better management and better reputation. In addition, foreign banks have better access to cheaper funds not available to domestic banks. In some countries, depositors have little confidence in domestic banks, thus they direct their deposits to foreign banks that provide more security and confidence. As a result, the domestic banks would have to pay substantially higher interest rates to attract depositors.

The literature on foreign banks' entry to local banking markets frequently asserts that entry to the domestic banking market can make the national market more competitive and thereby encourage banks to operate efficiently (Claessens et al., 2001). De Young and Nolle (1996), Jayaratne and Strahan (1998) and Evanoff and Ors (2003) argue that the elimination of entry barriers should lead to efficiency gains, as banks recognise that their domestic market will not be protected by the regulator. The removal of entry barriers will place competitive pressure on domestic banks in the local market to improve operations to remain as a feasible competitor.

The impact of foreign bank entry on the efficiency levels of a local banking market has been the subject of many studies. In general, most studies in developing countries found that foreign banks contributed positively to increasing the level of competition and efficiency levels. Most of the studies also showed that foreign banks are more efficient than domestic banks (Isik and Hassan, 2002; Hao et al., 2001; Harvylchyk, 2006; Kraft et al., 2006). Section 3.6 reviews studies that have examined the impact of deregulation and foreign bank entry on the level of banks' efficiency.

3.4 Why Frontier Efficiency Analysis in the Banking Industry?

Following the discussion of the possible impacts of deregulation and foreign bank entry on the efficiency of the banks, this section outlines the importance of using frontier analysis in banking. The frontier analysis could be a useful tool, providing guidance to regulators and policy makers regarding policies adopted and their effect on bank performance.

Banks are increasingly using benchmarking techniques to identify operations needing improvement by comparing their performance with other banks in the industry and accounting-based ratios are a traditional tool to measure efficiency (De Young, 1997). With ratio analysis, a peer group of banks with similar characteristics should be constructed. The constructed ratios assume that all banks have the same characteristics. However comparing the financial ratios of different banks is not an appropriate tool in measuring the best performance unless the banks are almost identical in product mix, bank size, market conditions, ownership structure and any other characteristics that can affect banking performance (De Young, 1997). An important class of benchmarking methods used in the banking market is frontier efficiency analysis. DeYoung (1997) argues that frontier efficiency analysis is superior to accounting-based efficiency analysis because with frontier efficiency analysis there is no need to construct peer groups of banks with similar characteristics. Rather, it uses linear programming and statistical techniques to remove the effects of differences in input prices and other exogenous market factors affecting standard performance ratios (e.g. return on assets (ROA), return on equity (ROE)) so that a better estimate of the underlying performance of the managers may be obtained. Bauer et al. (1998) point out that frontier efficiency analysis is more useful for regulatory, financial institution managers and industry consultants to assess banks' performance. It may be used in a number of ways to help a bank evaluate whether it is performing better or worse than its peer groups in technology, scale, cost minimisation and profit maximisation. Thus management efforts can be directed to the areas most needing improvement.

Similarly, Cummins and Weiss (1998) point out how frontier efficiency methods are useful in many situations. Firstly, frontier analysis provides guidance to regulators and policy makers regarding policies adopted and the effect of that on bank performance. Second, to inform management about the effects of policies, procedures, strategies and technologies adopted by the firm in relation to efficiency (performance). Third, they are important in testing some economic hypotheses in regard, to both agency and transaction costs. Through such measurement, economists can predict whether the ownership structure of firms influences their economic behaviour. In particular, the measurement of efficiency can attempt to evaluate whether cost and profit inefficiencies are related to ownership structures (Altunbas et al., 2001). For example, an analysis of the impacts of ownership structure on efficiency has implications for which kind of ownership (e.g. public or private domestic or foreign) can best achieve high levels of efficiency (Isik and Hassan, 2003). Finally, frontier analysis is useful to compare banks' performance (efficiency) across different countries. For example, in the case of bank efficiency, Berg et al. (1993) compared the relative efficiency of Nordic banks.

3.5 Specification of Banks' Inputs and Outputs

As indicated in Chapter 2, when measuring efficiency by using frontier approaches, one first needs to specify inputs (x_i) and outputs (y_i) of banks under consideration. This section outlines the choice of bank inputs and outputs typically used in the bank efficiency literature. Defining outputs of a banking firm has been a challenging task for researchers. Unlike manufacturing firms, banks' outputs cannot be measured by physical quantities, as a bank is an entity engaged in the intermediation of services between lenders and depositors. Banks provide a wide array of services such as low risk assets, credit and payment services and running investment portfolios (Molyneux et al., 1996). In addition, banks are multi-product institutions; many of their services are jointly or independently produced (e.g. different kinds of loan, investments). The precise definition of what banks produce and how their products should be measured have been the subject of much debate among researchers (Goddard et al., 2001). However, there are two main approaches use by researchers to identify banks' outputs and inputs: the production approach and the intermediation approach.

With the *production approach,* banks are viewed as firms which employ capital and labour as inputs to produce different types of deposit and loan accounts. Outputs are then measured by the number of deposit and loan accounts or by the number of transactions performed on each type of product and total costs are the operating costs (excluding interest costs) used to produce the products (Molyneux et al., 1996). The main shortcoming of this approach is that it does not take into account the interest expenses banks incur, which for most banks, forms more than 60 per cent of total costs (Molyneux et al., 1996; Goddard et al., 2001). In addition, it is difficult to obtain data for the number of deposits and loans accounts or the number of transactions performed for a given time.

The alternative *intermediation approach,* proposed by Sealey and Lindley (1977), assumes that banks collect deposits to transform them, using labour and capital, into loans, investments and other earning assets (e.g. balances with other banks). In short, it views banks as intermediators of financial services. Thus, loans, investments and other earning assets are considered as the bank's output measures and, labour, capital and deposits are considered inputs measures and total costs are the operating and interest expenses. With this approach, therefore, the selection of outputs and inputs is based on the bank's balance sheet data (i.e. assets and liabilities) (Matthews and Thompson, 2005). The main advantages of the intermediation approach over the production approach are that the intermediation approach treats deposits as inputs, which is more convincing, since banks use deposits (as well as other funds) to make loans and investments (Elasiani and Mehdian, 1990). Additionally, Berger and Humphrey (1997) argued that intermediation has the advantages of being more inclusive and capturing the essence of a financial intermediary, as banks buy rather than sell deposits. Therefore, the intermediation approach has been the most widely used in the empirical bank efficiency literature (e.g. Aly et al., 1990; Berger and Mester, 1997; Altunbas et al. 2001; Bos et al., 2009)

3.6 Efficiency in Banking Industries: Empirical Evidence

Early studies looking of the banking industry concentrated on scale and scope efficiencies (Berger et al., 1993). Berger et al. (1993) summarised the previous results of scale economies' studies in the banking industry and found that average cost has a relatively flat U-shape. Medium-sized banks with assets volume of $100 million- $10 billion are more cost-scale efficient than small and big banks. These studies attempted to analyse the presence of scale economies (i.e. working at the minimum efficient scale) rather than cost/profit efficiency, and assumed that banks always operate on their minimum cost frontier, which means that frontier inefficiencies (e.g. cost inefficiency) do not exist (Sheldon, 1999; Drake 2003). Berger and Humphrey (1991) invalidated this assumption through their study on a sample of U.S banks, which found that the frontier inefficiencies not only existed but were of more importance than the study of scale and scope economies (Tables 3.1 and 3.2 summarise the early studies in the US and the European banking industries). Berger et al. (1993) indicated that cost inefficiencies in banking accounted for approximately 20 per cent or more of banking costs, whilst scale efficiencies (when they can be accurately estimated[36]) are usually found to account for less than 5 per cent of costs. Therefore, since the early 1990s, the analysis of efficiency within the banking industry has concentrated on cost and profit efficiency. Berger and Mester (1997) determined three concepts that offer a definitional framework for the testing of cost and profit efficiency in the banking industry: cost efficiency, standard profit efficiency and alternative profit efficiency (these three concepts are examined in the methodology chapter). The efficiency studies within the banking industry were mainly aimed at, as summarised by Berger and Humphrey (1997):

1. Providing information to policy makers regarding policies such as deregulation, financial disruption, bank failure, risk, problem loans and

[36] For more details about the problem of estimation of scale efficiency, see Berger and Humphrey (1994).

market structure and concentration. Examples include Berg et al. (1993), Humphrey and Pulley (1997), Vivas (1997), Gilbert and Willson (1998), Jayaratne and Strahan (1998), Alam (2001), Berger and Mester (2003), Bertrand et al. (2007).

2. Improving managerial performance through determining the characteristics of less efficient banks. Example include Vassilogou and Giokas (1990), Fried et al. (1993), Tulken (1993), Drake and Howcroft (1994), Berger and De Young (1997), Spong et al. (2005), Howland and Rowse (2006), Portela and Thanassoulis (2007).
3. Testing certain conceptual issues such as corporate control, organisational form, principal-agent relationships, ownership structure, mergers and the level of risks taken by banks. Examples include Altunbas et al. (2001), Isik et al. (2003), Halkos and Salamouris (2004), Erdem and Erdem (2008).
4. Comparing the performance of banks in different countries. Examples inclyde Allen and Rai (1996), Sheldon (1999), Altunbas et al. (2001), Casu and Molyneux (2003), Casu and Girardone (2006).
5. Comparing efficiency scores using different frontier approaches and comparing cost and profit efficiency. Examples are Berger and Mester (1997), Vivas (1997), Rogers (1998), Bauer et al. (1998), Maudos et al. (2002), Maudos and Pastor (2003), Fiorentino et al. (2006), Delis et al., (2009).

Despite the extensive literature that has examined efficiency within the US and European banking industries (Table 3.3 and 3.4 review the main efficiency studies), limited studies have been conducted on developing countries (Table 3.5 reviews the main studies), especially in Middle Eastern countries such as Jordan. This can in part be attributed to the fact that the banking system in these countries is less established and is still being developed and, more importantly, is still characterised by government control. However, during the last two decades, banking industry circumstances in developing countries have undergone wide-ranging change, including the globalisation of the financial markets accompanied by government deregulation, privatisation, economic reforms and financial innovation. The above factors and changes which have arisen within the developed countries' banking industries have provided an incentive to researchers to change in efficiency levels in developing countries, for many reasons.

Firstly, an empirical investigation of efficiency levels will help policy makers to assess the extent to which their policies were successful in improving the efficiency of the banking system. Secondly, these studies will also help the financial institutions themselves to improve levels of efficiency, in order to be able to compete nationally and internationally and to remain in the market. Thirdly, different market structures in developing countries may have different implications for bank efficiency. In the context of this research, the main studies to test the impact of deregulation on banks' efficiency level and to test such conceptual issues (i.e. ownership structure, risk, specialisation and corporate control) and their impacts on the level of efficiency will now be highlighted, with particular emphasis on the studies in developing countries.

3.6.1 Impact of Deregulation on Bank Efficiency

1. Studies in developed countries.

US deregulation occurred in the early 1980s and the main reforms that took place within the US banking industry include a ceiling on interest rates being eliminated, the allowing of interstate branch expansion, thrift institutions being allowed into consumer and business lending and affiliates of banks being permitted some degree of securities underwriting (Winston, 1998). The relationship between deregulation and efficiency within the US banking market has been tested by many empirical studies (e.g. Humphrey, 1991; Berger and Humphrey, 1992; Bauer et al., 1993; Humphrey, 1993; Elyasiani and Mehdian, 1995; Wheelock and Wilson, 1999; Berger and Mester 2003).

Humphrey (1991) analysed the relationship between deregulation and productivity for US banks in the years 1977-1987, using a non-parametric approach (DEA), and found that there was a very low to negative productivity growth as a result of deregulation. Humphrey (1993) replicated his previous study but adopted a parametric approach and found that the largest bank experienced negative productivity growth.

Berger and Humphrey (1992) employed a parametric approach (i.e. TFA) and used data for the year 1980 to estimate cost efficiency. They measured technical change and productivity and found little change in these measures during the 1980s.

Bauer et al. (1993) measured efficiency level for the period 1977-1988, using parametric approaches (i.e. SFA and TFA). They found little improvement in the efficiency scores during the study period.

Elyasiani and Mehdian (1995), working with US data, selected from 1979 and 1986 as rough proxies for the pre- and post-deregulation periods. Using DEA, they calculated efficiency scores for samples of US banks from these two years. They found the efficiency scores for the year 1986 better than for 1979. Also, they found the technical efficiency declined by 3% for large banks. This means that the efficiency of banks improved as a result of deregulation.

Wheelock and Wilson (1999) analysed the productivity of the US banks during 1984-1993 using a non-parametric approach (DEA). Wheelock and Wilson (1999) found during 1984-1993 that banks experienced a decline in technical efficiency.

Alam (2001) found that the productivity of US banks regressed between 1980-1983, following deregulation, but post-1985 there was increase in profit productivity. Alam's results are consistent with Humphrey and Pulley's (1997) findings, when they analysed the technological and efficiency effects of deregulation in terms of profit functions. This study concluded that adjustment to deregulation usually takes four years and that this is attributed to banks' adjusting to deregulation through three processes:

1. Cost offset and reduction: At this stage, banks offset higher costs by reducing other costs, such as branch operating costs.

2. Cost shifting: With this, higher funding costs and interest rates will be shifted to the borrower through floating rate loans.

3. Profit augmentation: Banks expand their assets with more risky assets, in order to enhance profits

Berger and De Young (2001) employed a parametric approach (DFA) using data for the period 1993-1998 to assess the effects of geographic expansion on banks' cost and profit efficiency. They found that the geographic expansion had positive effects on both. That is some efficient banks can export efficient practices to other banks.

Berger and Mester (2003) investigated the effects of technological change over the deregulation period and beyond (1984-1997). Their results showed that cost productivity worsened by 4.2% annually between 1984-1991 and by 12.5% annually between 1991-1997. However, profit productivity improved by 4.3% annually between 1988-1991 and by 12.2% annually between 1991-1997.

To summarise, the US deregulation experience showed that cost productivity worsened and profit productivity improved after deregulation. Berger and Humphrey (1997) pointed out that a possible explanation of their findings is that there was an increase in market power between 1991 and 1997, which enabled banks to set high output prices. Moreover, the US studies concluded that adjustment to deregulation usually takes four years.

Berg et al. (1993) analysed the performance of the Nordic countries during the period 1984-1990, using a nonparametric approach (i.e. DEA) to investigate the impact of deregulation on the efficiency of Norwegian banks, before and after deregulation. The main finding was that there was a decline in productivity pre-deregulation and an increase post-deregulation: this gain in productivity is related to banks' becoming more efficient after the deregulation. This deregulation includes remove entry barriers among European countries.

The effects of deregulation on the cost efficiency of the Spanish banks was analysed by Grifell and Lovell (1996) and Vivas (1998) and both studies found that cost efficiency was not improved as a result of deregulation. Vivas (1997) used parametric techniques (TFA) to determine how deregulation affected the profit efficiency of Spanish savings banks between the years 1986-1991. He found that there was no significant decrease in inefficiencies, despite the introduction of deregulation. Similarly, Kumbhakar et al. (2001) used a parametric approach (SFA) to investigate the effects of deregulation on the performance of Spanish saving banks over the period 1986-1995 and their results reveal a high level of technical inefficiency, along with a very high rate of technical progress. Therefore in the case of Spanish bank it would be appear that the deregulation has no impact on the efficiency of banks.

Canhoto and Dermine (2003) examined the impact of deregulation on the efficiency of the Portuguese banking industry, using DEA, over the period 1990-1995. The deregulation process began in 1984 with authorised entry into the banking market, in addition to removing the credit ceiling and ceilings on interest rates and allowing freedom to open new branches. The study concluded that there was an improvement in the level of efficiency up from 59% to 84% after deregulation.

The deregulation of financial services within the European Union, which aimed to remove entry barriers and to foster both competition and efficiency within European banks, was analysed by Casu and Girardone (2006). Using DEA and working with European data selected from 1997 and 2003 as rough proxies for the pre- and post-deregulation periods, they calculated efficiency scores using samples of European banks from these two years. They also used the Panzar and Rose model[37] (H statistic) to assess the degree of competition within the European countries. To test the link between competition and efficiency, the H statistics (as a measure for competition levels) were regressed against measured efficiency levels with other explanatory variables (independent variables). The authors found little evidence that more efficient banking systems are also more competitive: the relationship between competition and efficiency is not as straightforward as this. Therefore increased competition has forced banks to become more efficient but increased efficiency has not resulted in more competition within EU banking systems.

Bertrand et al. (2007) investigated how the deregulation of the French banking industry in the 1980s affected the behaviour of banks. Their analysis suggested that a reduction of government intervention in the banking sector was associated with a more efficient allocation of loans across banks. They also found that less government intervention is accompanied with major changes in the structure of the product market, with an increase in banks' entry and exit rates, a reduction in the level of product market concentration and a progress in the allocation of assets and jobs across banks.

[37] Panzar and Rose (1987) developed a model of oligopolistic, competitive and monopolistically competitive markets and derived test statistics to distinguish among them. The H statistic test is the sum of elasticities of total revenue with respect to input prices. The inferences that can be drawn from the numerical value of H are as follow: H equal to zero or negative indicates oligopoly or monopoly; equal to one indicates a perfectly competitive industry; $0 < H < 1$ indicates the intermediate case of monopolistic competition.

2. Studies in developing countries' banking Industry

Gilbert and Willson (1988) examined the impact of liberalisation on the productive efficiency of Korean banks between the years 1980-1994. Their results indicated that government control tends to limit incentives and the ability of managers to operate efficiently. Thus, the gradual deregulation of the Korean banking industry contributed positively in improving the productivity of Korean banks. Another study, conducted by Hao et al. (2001) investigated whether the further deregulation within the Korean banking industry in 1991 led to further improvements in productive efficiency. The research employed parametric techniques SFA and involved studying a sample of data covering the period 1985-1995. In contrast to Gilbert and Willson (1988), Hao et al. (2001) concluded that further deregulation did not improve productive efficiency.

Leightner and Lovell (1998) investigated the impact of deregulation on efficiencies within the Thai banking system: they used nonparametric techniques to see annual productivity growth for Thai banks over the period 1989-1994. Their results indicated that productivity of the banks was improved and also the liberalisation significantly increased the competitiveness of the Thai banking industry by making Thai banks compete with each other and with international banks (i.e. foreign banks operating in Thai). In contrast to the above study, Williams and Intarachote (2002) and Okuda and Mieno (1999) found that banking efficiency in Thai banks decreased after deregulation.

Katib and Mathews (2000) and Okuda et al. (2002) examined the impact of deregulation and technological change on the productivity and efficiency of Malaysian banks. The deregulation process included the Central Bank of Malaysia removing administrative control over interest rates and the study's results indicated that financial liberalisation was accompanied by an increase in banks' operational costs and a negative progress in technology. Also, the productivity of Malaysian banks declined during the liberalisation period: an increase in operational costs and a decrease in productivity indicated that output was growing at a lower rate than input.

Hardy and de Patti (2001) used the parametric technique DFA to investigate the effect of financial reform on the efficiency of Pakistani banks. Their results indicated that, during the post-deregulation period (1993-1997), both cost and revenue increased. Thus, they concluded that the benefits of an increase in revenue efficiency were transferred to customers (i.e. borrowers and depositors). Ataullah et al. (2004) argued that it is difficult to justify Hardy and de Patti's conclusion regarding the improvement in revenue efficiency being transferred to the customers, as the interest rate margin within the banking industry in Pakistan increased significantly after deregulation: the banks charged higher interest rate on their loans, but did not increase interest rates on deposits.

Kumbhakar and Sarkar (2003) examined the relationship between deregulation and productivity growth in India's banking industry during the period 1985-1996 and concluded that there was an extensive over-employment of labour relative to capital throughout the entire study period, finding little evidence to suggest that deregulation improved the productivity of banks. Ataullah et al. (2004) measured the technical efficiency of Indian and Pakistani banks before and after the adoption of the financial liberalisation programme. They used a nonparametric methodology (DEA) and their results showed that the overall technical efficiency of the banking industry in both countries has progressively improved over the years, especially after 1995. The improvement in India was due to improvements in both pure technical and scale efficiency. Their results also showed that public and foreign banks to be less efficient than private domestic banks.

Zaim (1995), Kasman (2002) and Isik and Hassan (2003) found a positive relationship between the deregulation of banks and efficiency in the Turkish banking industry. Isik and Hassan (2003) examined the impact of liberalisation on productivity growth, efficiency change and technical progress in that industry during the decade 1980-1990. Throughout the 1980s, a series of financial restructurings took place, aiming to strengthen the efficiency and productivity of banks by limiting government intervention and enhancing the role of market forces. Interest rates and foreign exchange were freed, industrial and new financial businesses were allowed to operate and new product restrictions were removed, as were directed credit programmes and restricted rates. The results showed that the performances of all types of banks improved after deregulation. Productivity growth in Turkish banking also increased, due to an increase in banks' efficiency rather than technical progress and inefficient banks enhanced their productivity by improving their operations and becoming close to best practice banks. Isik and Hassan (2003) demonstrated how an improvement in the productivity and efficiency of the Turkish banks was low in the early years of liberalisation (1980-1984), yet banks need time to adapt to new regulations. This is in line with empirical evidence by Humphrey and Pulley (1997) who found that US banks needed four years to adjust to new regulations.

Williams and Nguyen (2005) investigated the relationship between bank performance and bank governance and the impact of deregulation in South East Asia (Indonesia, Korea, Malaysia, Philippines and Thailand) banks during the period 1990-2003, using the parametric approach (SFA). Their results indicated that bank privatisation was accompanied by superior profit efficiency performance in comparison with other types of bank governance. Also, they found that privatisation contributed positively to increasing banks' productivity. With regard to the efficiency and productivity of banks owned by foreign institutions, their results suggested that profit efficiency of these banks was improved but their productivity was not.

Cook et al. (2001) examined the relationship between deregulation and bank efficiency in the Tunisian banking industry over the period 1992-1998, using a nonparametric approach (DEA). The banking system in Tunisia was characterised by heavy government intervention such as imposing credit allocations, placing ceilings on interest rates and limiting foreign presence in the financial sector. Banks did not have the authority to lend more than a specific amount determined by the Central Bank: any loans exceeding this amount needed the approval of Central Bank. Banks were also required to hold up to 20% of their assets in government bonds and to allocate a fixed percentage of their deposits for lending at preferred interest rates to specific sectors. The deregulation process took place in Tunisia in 1987; interest rates were liberalised, the amount of treasury bills banks were required to hold was reduced in 1991 and restrictions on the presence of foreign banks were also removed in 1991. Ultimately, the study results indicated that the deregulation process did not positively contribute to efficiency levels in Tunisian banks.

To sum up, the empirical evidence on the impact of deregulation on banks' efficiency has been mixed (i.e. some studies reported a positive impact and others reported negative impact). Berger and Humphrey (1997) pointed out that the results of deregulation may essentially depend on whether the conditions of the industry have been regulated and on the type of deregulation measures implemented. Also, the institutional environment of the banking system plays a vital role in determining how deregulation affects on banks' efficiency. For example, Demirguc-Kunt and Detragiache (1999) mentioned that countries with weak institutional environments, characterised by weak legal enforcement, inefficient bureaucracy and corruption are subject to instabilities within their financial system after deregulation. Thus deregulation could lead to a decrease in banks' efficiency in the period following liberalisation.

3.6.2 Foreign Banks and Domestic Banks

Another strand of studies related to banks' efficiency look of how the entry of foreign banks has affected local banks efficiency and on whether foreign banks are more efficient than local banks. In this section, many of the studies examining the effect of entry of foreign banks on efficiency will be reviewed. Moreover, it will review some studies comparing the efficiency of both foreign and local banks.

1. The Impact of the Entry of Foreign Banks into Developing Countries on the Efficiency of Domestic Banks

Using 7900 bank observations from 80 countries for the period 1988-1995, Claessens et al. (2001) examined the effects of the presence of foreign banks within domestic banking markets. Their findings indicated that foreign banks tended to have higher interest margins and higher profitability than domestic bank in developing countries, whilst the opposite was true in developed countries. The research concluded that, in the long term, foreign banks' entry to local markets puts pressure on local banks to improve their services and operations; thus, local banks eventually became more technically and allocatively efficient by trying to control their operational costs.

Sturm and Williams (2004) used nonparametric (DEA) and parametric (SFA) approaches to examine the impact of foreign bank entry on banking efficiency in Australia during the post-deregulation period 1988-2001. As a result of Australian deregulation in 1981, sixteen foreign banks entered the Australian system in 1985. The Reserve Bank of Australia assumed that the foreign banks' entry would increase competitiveness and efficiency in Australian banks, but Sturm and Williams' (2004) results indicated that foreign banks were more input efficient than local banks. Also, their results showed that foreign banks proved an important source of efficient technological changes immediately after deregulation. They concluded that regulators should encourage diversity amongst banks as a source of ongoing efficiency and innovation within the banking market. Thus the entry of foreign banks to the Australian banking market put pressure on local banks to adapt new technology and therefore enhancing their efficiency.

Kraft et al. (2006) investigated the effects of privatisation and bank entry on efficiency levels within the Croatian banking market; they also analysed the relative efficiency of state-owned, private and foreign banks. They used a parametric approach (SFA) to estimate cost efficiency scores for the period 1994-2000, a period characterised by the privatisation of state-owned banks and the entry of foreign banks into the local market. The results showed that foreign banks were more efficient than domestic bank and also that the efficiency levels of local banks did not improve after liberalisation. The main policy implication from the study indicated that liberalisation in the form of opening the banking market to did not help to enhance efficiency levels for local banks.

Unite and Sullivan (2003) examined the response of domestic Philippine banks to allowing foreign banks entry and foreign ownership in the Filipino banking industry in the years 1990-1998: the relaxation of foreign banks' entry to the Philippine banking market was initiated during the period 1992-1998. The findings indicated that interest rate spreads became narrower and operating expenses decreased as a result of greater foreign bank entry; the results also show that competition within the banking industry increased as a result of the entry of foreign banks. Unite and Sullivan (2003) concluded that foreign competition induced local banks to be more efficient through competitive pressures which forced banks to improve lending practices and allocate their resources efficiently.

To sum up, the above studies showed the entry of foreign banks to local banks helped in the improvement of the competition and the efficiency within the local market. The introducing of foreign banks to local banking market helps in the introducing of new technologies to the local market, which in turn motivated local banks to adapt these technologies to improve their operations.

2. Efficiency of Foreign Banks vs. Domestic banks

Another strand of the efficiency literature aimed to compare the efficiency levels of foreign banks against that of local banks. Developed countries studies of US data generally found that foreign-owned banks are significantly less cost efficient on average than domestic banks (Hasan and Hunter, 1996; Mahajan et al., 1996; Chang et al., 1998) and less profit efficient on average than domestic banks (De Young and Nolle, 1996).

Hasan and Hunter (1996) studied the cost efficiency of Japanese multinational banks operating in the US by using data for the period 1984-1989 and a parametric approach (SFA). They found that that the Japanese banks were significantly less cost efficient than the US ones.

Mahajan et al. (1998) compared the efficiency of foreign banks in the US with that of US banks during the period 1987-1990 using a parametric approach (TFA). They estimated two frontiers, one for foreign banks and the other for US banks and found that the average cost efficiency for US banks was significantly more than the average cost efficiency for foreign banks.

Chang et al. (1998) made a comparative analysis of the productive efficiency of foreign-owned and US-owned multinational commercial banks operating in the US over the period 1984-1989. A parametric approach (SFA) was used to estimate cost efficiency scores for both sets of banks. Their results indicated that foreign-owned multinational banks operating in the US are significantly less cost efficient than domestically owned US banks.

De Yong and Nolle (1996) estimated the profit efficiency of foreign banks working in the US and US banks over the period 1985-1990 with a parametric approach (SFA). Their main findings refer to foreign banks' being less profit efficient than US banks.

Berger et al. (2000, 2005) in a multinational study estimated the cost efficiency for foreign banks operating in France, Germany, Spain, UK and USA over the period 1993-1998. They used a parametric approach (DFA) and found that foreign banks were less cost efficient than local banks in the countries under study.

To sum, the literature in the efficiency of foreign banks operating in developed countries shows that the local banks are more efficient than foreign banks. Isik and Hassan (2003) attributed that to that foreign banks in developed countries usually finance their operations by depending on purchased funds, which is more expensive than core deposits (Isik and Hassan, 2003).

With regard to studies in developing and emerging countries, most studies found that foreign banks are more efficient than domestic banks (e.g. Bhattacharyya et al., 1997; Hao et al., 2001; Isik and Hassan, 2002; Grigorian and Manole, 2002; Bonin et al., 2005; Havrylchyk, 2006; Kraft et al., 2006).

For example, Bhattacharyya et al. (1997) measured technical efficiency for Indian banks during 1986-1991 using a nonparametric approach (DEA). Within their study, they compared the efficiency level for foreign banks against domestic banks. Their findings refer to foreign banks' being more efficient than domestic banks.

Isik and Hassan (2002) estimated the cost and profit efficiency for Turkish banks using a parametric approach, and data for the years 1988, 1992 and 1996. They compared efficiency scores for local and foreign banks and found foreign banks to be more efficient than domestic banks.

Bonin et al. (2005) using data from 1996 to 2000, investigated the effects of ownership on bank efficiency for eleven transition countries. Applying stochastic frontier estimation procedures, they measured profit and cost efficiency and found that foreign banks were more cost and profit efficient than domestic ones.

After the collapse of communism in Poland in 1989, many foreign investors entered the Polish banking market by the acquisition of privatised local banks or the establishment of new subsidiaries in Poland. Havrylchyk (2006) investigated the efficiency of the Polish banking industry in the period 1997-2001 to determine the differences in efficiency between foreign and local banks. Havrylchyk (2006) used a nonparametric approach (DEA), to distinguish between cost, allocative, technical, pure technical and scale efficiencies and his results indicated that foreign banks were more efficient than domestic. Also, foreign banks showed higher productivity in the level of outputs and were superior to domestic banks in using the right mix of inputs in the light of given prices. The study's results suggested that foreign bank managers were more capable of managing their costs and screening borrowers. On the other hand, foreign banks that acquired domestic banks did not appear as efficient as the foreign banks opening new subsidiaries in Poland.

3.6.3 Correlates of Bank Efficiency (Factors affecting efficiency scores)

Another strand of literature attempts to determine factors that may have an impact on efficiency scores (i.e. bank-specific factors and environmental variables). In the context of banks in developed and developing countries, many studies have tried to investigate the factors that may explain the variation in efficiency and to determine the characteristics of the most and least efficient banks (e.g. Kwan and Eisenbeis, 1996; Mester, 1996; Resti, 1996; Berger and Mester, 1997; Worthington, 1998; Berger and Hannan, 1998; Altunbas et al., 2001; Casu and Molyneux, 2003; Isik and Hassan 2003; Tortosa-Ausina, 2004; Hassan, 2005; Bos et al., 2009). In general, these studies used the internal bank-specific variables (e.g. risk, loan quality) and environmental variables (e.g. concentration level) as factors that may explain the variations in the efficiency levels among banks. To investigate the effects of the above factors, the existing literature uses the following approaches to assess the impact of various factors on bank efficiency:

1. Two-stage analysis: The first stage involves estimating a conventional frontier with traditional inputs and outputs, while the second involves the regression of these predicted cost and profit efficiencies scores onto the explanatory variables (i.e. bank-specific and market condition variables). Examples include Berger and Mester (1997), Casu and Molyneux (2003) and Isik and Hassan (2003). However, the two-stage analysis has many shortcomings which will be mentioned in Chapter 5 (methodology chapter).

2. One-stage analysis: This approach involves estimating the cost/profit frontier in one-stage, through introducing explanatory variables (i.e. bank-specific and market condition variables) directly into the estimation of cost and profit efficiency. Examples include Mester (1996), Worthington (1998), Al-Jarrah and Molyneux (2003) Fries and Taci (2005), Pasiouras et al. (2008), Bos et al., (2009). The details of this approach will be discussed later in Chapter 5 since it will be adopted in this research.

Mester (1996) estimated the cost frontier for US banking over the period 1991-1996 using the parametric approach (SFA) and including directly into the estimation (i) the level of bank equity as a proxy for the difference between banks in terms of risk attitudes and (ii) non-performing loans as a proxy for the quality of bank loans. Mester (1996) reported that including variables to control for bank risk and the quality of loans has a direct effect on the estimated cost efficiency scores.

Kwan and Eisenbeis (1996) examined the relationship between estimated cost efficiency scores and the attitude of banks towards risk. Kwan and Eisenbeis (1996) used a second stage analysis by regressing the cost efficiency scores from the first stage against some explanatory variables that proxy for risks (e.g. the ratio of equity to total assets, the ratio of loan provision to total loans). Kwan and Eisenbeis (1997) reported that less efficient banks are have higher risk than efficient banks.

Worthington (1998) estimated the cost efficiency of Australian banks over the period 1992-1995 by using a parametric approach (SFA) and one-stage analysis. Worthington (1998) investigated the impact of capital adequacy and bank size on the level of cost efficiency. Worthington (1998) reported that the capital adequacy does not impact on cost efficiency, whereas asset size affected it positively.

Berger and Mester (1997) estimated the cost and profit efficiency of US banks over the period 1990-1995 using parametric approaches (SFA and FDA). They investigated the impacts of many variables (e.g. age of banks, concentration, asset size) on the level of efficiency by adopting second-stage analysis. Berger and Mester (1997) found big (i.e. banks with assets size exceeds 1 billions US Dollars) banks and old banks more efficient than small and new ones. Also, they reported that banks operating in a more concentrated market are less efficient than those in a less concentrated one. Subsequently, Berger and Hannan (1998) examined the relationship between cost efficiency scores and the level of concentration and they reported that banks operating in a more concentrated market were less cost efficient than those in a less concentrated one.

Altunbas et al. (2001), with parametric approaches (SFA and FDA), investigated the impact of different ownership structure (private, public and mutual banks) in German banks cost efficiency using two stage analysis. They found that privately-owned are more efficient than mutual and public banks.

Casu and Molyneux (2003) used a nonparametric approach (DEA) and data for the period 1993-1997 for five European countries to investigate factors that maybe have an impact on efficiency. They used second stage analysis by regressing the efficiency scores obtained from DEA against candidate variables. These variables were equity to total assets, average return on equity, dummy variable for kind of bank and dummy variable for the bank is listing on the stock exchange. They reported that the equity ratio and the kind of bank (e.g. commercial or investment) do not have an impact on efficiency, whereas the return on equity is positively related to efficiency scores.

Tortosa-Ausina (2004), with a nonparametric approach (DEA), investigated the impact of specialisation, ownership type and size of bank on the efficiency of Spanish banking firms. He reported that specialised banks were less efficient than commercial banks and also that bank size is positively related to efficiency scores. Tortosa-Ausina (2004) also found specialised banks less efficient as they produce distinct services and different product mixes requiring a more intense input use and more specialised personnel.

Hassan (2005) examined the cost and profit efficiency of Islamic banks worldwide using a parametric approach (SFA) for the period 1996-2003. He reported that Islamic banks were less cost efficient and more profit efficient than commercial banks and attributed that to the fact that the Islamic banks produce distinct services and different product mixes requiring a more intense input use and more specialised personnel. He attributed the superiority of Islamic banks in profit efficiency to the Islamic banks not dealing with risky assets such as derivatives and dealing with real assets, which in turn suggests that the Islamic banks are not facing the risks facing commercial and investment banks.

Bos et al. (2009) used a parametric approach (SFA) to measure the cost efficiency for German banks over the period 1993-2005. They investigated the impact of heterogeneity among banks regarding estimated cost and profit efficiency by using one-stage analysis. They used many variables to control for heterogeneity among banks such as the level of equity, bank type, regional location and bank size. They reported that the cost and profit efficiency scores are underestimated if not controlling for heterogeneity among banks.

To sum up, in investigating and controlling for the factors that may have impact on banks' efficiency, it is very important to explore the main characteristics of more and less efficient banks. This is particularly relevant to this study as this research endeavours to apply one-stage analysis and looks for the factors that maybe have an impact on the level of Jordanian banks' efficiency.

3.6.4 Comparing Efficiency Scores from Parametric and Nonparametric Approaches

Another strand in the literature compares the efficiency scores from the two approaches (i.e. parametric and nonparametric) used in the literature to estimate banks' efficiency. This strand of literature is aiming to establish a consistency between the scores obtained from the two different approaches (see Bauer et al., 1998 consistency test in Chapter 2). A comparison between DEA and SFA in the banking industry has been offered by Ferrier and Lovell (1990), Resti (1997), Eisenbeis et al. (1999), Huang and Wang (2002), Weill (2004), Fiorentino and Koetter (2006) and Delis et al. (2009).

Resti (1997) and Eisenbeis et al. (1999) reported very high rank-order correlations between DEA and SFA, whereas Ferrier and Lovell (1990) found rank-order correlation between DEA and SFA very low.

Huang and Wang (2002), using a panel of Taiwanese commercial banks, reported that parametric and nonparametric methods generally produced different rank order for the efficiency scores among banks. However, they noted that both approaches yield similar average efficiency estimates.

Weill (2004) investigated the consistency of efficiency scores from DEA and SFA in a European banks' sample. He measured the cost efficiency of banks of five European countries (France, Germany, Italy, Spain and Switzerland), using DEA and SFA, and concluded that there was no consistency between the efficiency scores of the two approaches.

Fiorentino and Koetter (2006) investigated the consistency of cost efficiency measures for German banks derived from SFA and DEA. Their results indicated that the two approaches provided a reasonable ranking order between the efficiency scores derived from them. Moreover, they reported that DEA is particularly sensitive to measurement errors and outliers.

Delis et al. (2009) measured cost and profit efficiency for Greek banks over the period 1993-2005, using SFA and DEA. Their results suggest greater similarities between predictions of cost and profit efficiency scores from the two approaches.

Overall, the empirical evidence from the above studies suggests that the efficiency scores from parametric and nonparametric approaches are quite similar in terms of ranking of banks as most or less efficient. However, the nonparametric approach yields slightly lower efficiency scores than the parametric approach because the former does not account for the random errors.

3.6.5 Studies on the Jordanian Banking Industry

With regard to the Jordanian banking industry, the literature regarding bank efficiency is limited: only two studies tested the efficiency levels of Jordanian banks (Al-Jarrah, 2002; Isik et al., 2004).

Al-Jarrah (2002) used the SFA approach to examine efficiency levels in the Jordanian, Egyptian, Saudi Arabian and Bahraini banking systems during the years 1992-2000. To derive efficiency levels, he estimated three distinct economic efficiency concepts: cost, standard profit and alternative profit efficiencies. The banks' output in this study included loans, other earning assets and off balance-sheet items, while inputs included interest on deposits, total personnel expenses and expenses on land and buildings. The results indicated that cost efficiency averaged around 95% in 1992-2000 (89% for Jordan) and standard and alternative profit efficiencies averaged 66% and 58%, respectively, over the same period (66% and 50% for Jordan). The results also indicated that there were considerable differences in average bank efficiency levels across the four countries during the sample period, with Jordanian banks being the least cost and profit inefficient and Bahrain banks being the most efficient. Al-Jarrah (2002) also reported that the Islamic banks were found to be the most cost-and-profit efficient, with the large banks relatively more efficient.

Isik et al. (2004) used DEA to investigate managerial, pure technical and scale efficiencies of the banks operating in Jordan over the period 1996-2001. In estimating efficiency, the researchers constructed a year-specific production frontier and, to account for group effects, they normalised all inputs and outputs by the number of branch offices and calculated a separate frontier for each banking group. Additionally, they used two alternative approaches to measure banks' inputs and outputs (production and intermediation approaches). With the production approach, deposits are treated as bank outputs, whereas they are treated as bank inputs under the intermediation approach. Results for the production (intermediation) approach were 71% (89%) managerial efficiency, 89% (96%) pure technical efficiency and 79% (92%) scale efficiency. Although the two approaches produced different results the component of managerial efficiency under both approaches suggested that a major source of inefficiency within the Jordanian banking industry was scale inefficiency. In common with Al-Jarrah (2002), this study reported that large banks are the most efficient.

It should be noted that the two studies above did not take into account the foreign banks operating in Jordan, yet the 8 foreign banks operating within Jordan account for 41 per cent of the total number of banks in the country. Thus their exclusion from the data may have had an influence on the estimation of the efficient frontier for Jordanian banks. More importantly, none of these studies attempted to investigate the impact of deregulation on the efficiency levels in the Jordanian banking industry and the efficiency of foreign banks vs. the efficiency of domestic banks.

This section has focused on the academic literature that seeks to measure efficiency in banking industries. This literature was aimed to inform policy makers regarding their policies (e.g. the impact of deregulation on banks' efficiency), to investigate the main characteristics of the most and the least efficient banks in terms of ownership structure, size, age and specialisation, to test such conceptual issues (e.g. foreign banks vs. local banks) and to compare the consistency of estimated efficiency scores from parametric and nonparametric approaches. While a thorough literature search was made, a major limitation of the bulk of the academic literature is that it focuses mainly on the cost side of banks' operations, ignoring the profit side. Berger and Mester (1997) showed that profit efficiency may not be positively correlated with cost efficiency, suggesting that the measure of profit efficiency may include output features reflecting higher quality or greater market power in pricing. Moreover, there have been surprisingly few attempts to compare cost and profit efficiency measures and even fewer to compare efficiency scores from parametric and nonparametric approaches. With regard to this research, cost and profit efficiency scores will be estimated for Jordanian banks using both approaches. This study covers the period both before and after the liberalisation process: this allows testing the impact of liberalisation on the Jordanian banks' efficiency. Moreover, one-stage analysis will attempt to reveal the main characteristics of the most and least efficient banks by incorporating some bank-specific variables directly in the estimation of cost and profit efficiency (this will be explained in detail in Chapter 5 on methodology). Moreover, a consistency test between SFA and DEA efficiency scores will be performed.

3.7 Conclusion

This chapter highlighted the importance of the existence of the financial system, especially banks, in the process of economic development and growth and then showed the related theories regarding the regulation and deregulation of the banking system, which aimed to establish an efficient banking system capable of promoting economic development and growth effectively. The chapter then showed the importance of using frontier analysis in banking industries as a tool to measure efficiency levels within the context of economic theory. This chapter also showed that there are two main approaches used to measure a bank's inputs and outputs as variables needed for frontier analysis.

This chapter also showed that in banking research, there is a large body of literature studying the efficiency of financial institutions, with an increasing focus on cost and profit efficiency. These studies suggest that cost and profit inefficiency in banking is accounting for more than 20 per cent of banks' costs/profits and dominating scale efficiency. Despite the extensive literature that has examined efficiencies in the US and European banking markets, limited studies have been made in developing countries, especially in Middle Eastern countries such as Jordan. The relatively limited studies on bank efficiency in these countries can be attributed to the banking system being less established and still being developed and, more importantly, is still characterised by government control. The chapter also showed that most of the studies on developing countries concentrated on the impact of deregulation on the improvement of efficiency levels. Moreover, it also showed that only a limited number of studies measured cost and profit efficiency and applied parametric and nonparametric approaches at the same time.

In the following chapter, the main structure of the Jordanian banks and the deregulation process which took place in Jordan will be reviewed, to see how the deregulation measures affected the structure of Jordanian banks' balance sheet and income statement.

Building in Chapter 2 (Efficiency Theory), Chapter 3 (Empirical Evidence) and the next Chapter (Jordanian Banking Sector) the main research hypotheses will be identified. These hypotheses will be tested, using two approaches (i.e. parametric and nonparametric approaches) in the methodology chapter.

Table 3.1 Scale Economies Studies in US Banking

Author	Data	Approach	Main findings and notes
Alhadeff (1954)	Data for 210 Californian branch and unit banks of different size using data 1938-50.	Financial ratios with earning assets as output (loans and investments to total assets) and operating expenses as cost. Relates ratio of operating expenses to earning assets in order to derive cost curve.	Increasing returns to scale for large and small banks and constant returns to scale for mid-sized banks. Major criticism of this study related to use of earning assets as measure of output and this measure did not include all assets. Exclusion of other assets tended to exaggerate average unit cost of large banks.
Horvitz (1963)	Data from annual reports of the Federal Reserve period 1940-60.	As above.	As above.
Schweiger and McGee (1961)	Data for 6233 banks for 1958.	Regression analysis. Dependent variable is ratio of current operating expenses to total assets and output measure is total deposits.	Large banks seem to have cost advantage over small and medium-sized banks.
Gramley (1962)	Data for 270 banks 1956-59.	Regression analysis. Dependent variable is ratio of current operating expenses to total assets and independent variable is total assets.	Average cost decreased as bank size increased. Therefore larger banks had cost advantage over small banks. Major drawback of this study is giving same weight for bank's output.
Greenbaum (1964)	Data for 745 individual member banks in Kansas City Federal Reserve District and 413 in Richmond District area 1960-1962.	Regression analysis. Divided output into two components: lending and all other.	Regressing current operating expenses on the output measure indicated U-shaped average cost curves in Kansas City District with optimal-size banks of approximately $300 million in deposits. Also, finding indicates cost reduction with increasing size of bank. Despite assigned weight for two outputs: lending output and all other. Lending output consists of many types and each type has different cost.
Benston (1965)	Data for 83 banks 1959-61.	Cobb-Douglas cost function.	Economies of scale present, but small for all banking services. Ranged 5%- 8%. Benston marked new direction for bank cost literature by employing Cobb-Douglas cost function. However, this is restrictive: can only show one of three possible outcomes- decreasing, constant or increasing average cost for all banks. Cannot show, for example, U-shaped average cost curve.
Mullineaux (1978)	Data for 892 banks 1971 and for 859 banks 1972.	Cobb-Douglas cost function.	Constant return to scale for branches, while increasing return to scale for unit banks.

(continued)

Table 3.1 Scale Economies Studies in US Banking (continued)

Author	Data	Approach	Main findings and notes
Benson Berger, Hanweck and Humphrey (1983)	Data for 1978 on commercial banks up to $1 Billon in deposits.	Translog cost function	Evidence of existence of U-shaped average cost curves. Unit banks with more than $50 million in deposit recorded diseconomies of scale, while branches experienced small economies of scale. Translog cost function allows for U- shaped average cost curves. However, one major shortcoming of translog cost function: gives poor approximation when applied to banks of all sizes, because it forces large and small banks to lie on symmetric U-shaped cost curves.
Kolari and Zardkoohi (1987)	Data 1979-1983.	Translog cost function	Economies of scale for banks with up to $50 million deposits and decreasing return to scale beyond $50 million.
Aly, Grabowski, Pasurka and Rangan (1990)	Data 1986 from 322 banks.	Nonparametric approach (DEA)	Economies of scale not more than 3%. To solve shortcomings of translog cost function, new generation of studies began to use A frontier approach, such as DEA.

Source: Greenbaum (1967), Goddard et al. (2001)

Table 3.2 Scale Economies Studies in European Banking

Author	Data	Approach	Findings
Gough(1979)	Data related to UK building societies 1972-1979.	Regression analysis	No evidence of scale economies for UK building societies.
Barnes and Dodds (1983)	Data from UK building societies 1970-78.	Regression analysis	No evidence of scale economies for UK building societies.
Cooper (1980)	Data 1977 from UK building societies.	Cobb-Douglas cost function	Evidence of scale economies with assets less than £100 million, and diseconomies of scale for larger building societies.
Fanjul and Marvell (1985)	Sample of 83 Spanish commercial banks and 54 saving banks 1979.	Cobb-Douglas cost function	Economies of scale in respect of accounts per branch and constant return to scale with respect to number of branches.
Hardwick(1989)	Sample of 79 UK building societies 1985.	Translog cost function	Evidence of scale economies for relatively smaller building societies.
Landi (1990)	Data from 295 Italian banks 1987.	Translog cost function	Evidence of scale economies for all bank sizes.
Pallage (1991)	Sample of 576 Belgian commercial banks, 24 savings and 3 public credit institutions.	Translog cost function	Evidence of scale economies for small banks; decreasing returns to scale when size grows.
Drake (1992)	Data from 1988 annual accounts for sample of 76 UK building societies.	Translog cost function	Study shows mild economies of scale evident only for societies in £120 - £500 million asset size range.
Rodriguez, Alvares and Gomez (1993)	Sample of 645 Spanish saving banks 1990.	Translog cost function	Economies of scale for medium-sized saving banks and diseconomies of scale for larger.
Molyneux et al. (1996)	Data from 201 French, 196 German, 244 Italian and 209 Spanish banks 1988.	Translog cost function	Results indicate noticeable differences in cost characteristics between countries and small and large banks suffering from economies of scale.
Ashton (1998)	Data from British retail-banking sector 1987-95.	Translog cost function	Slight diseconomies of scale when using intermediation approach in determining output but substantial diseconomies of scale when using production approach to measure bank's output.
Cavallo and Rossi (2001)	Data from 442 European banks 1992-1997	Translog cost function	Results support the view that the regulatory changes and progresses in technology have contributed to raising the optimal scale.

Source: Goddard et al. (2001) and author updated.

Table 3.3 Efficiency Studies in US Banking

Authors	*Approach*	*Sample*	*Nature of Study*	*Variables*	*Main Findings*
Berger and Humphrey (1992)	SFA	Data for 1980s	To analyse effects of deregulation on efficiency	Dependent variables: total costs. Outputs: real estate loans; commercial loans; individual loans. Input prices: price of labour; price of physical capital and price of funds.	Little change in technical efficiency and productivity as a result of deregulation.
Humphrey (1993)	TFA	Data for 1977 and 1988	To analyse effect of deregulation on cost efficiency.	Dependent variables: total cost (interest and operating expenses). Outputs: value of demand deposits; small time and savings deposits; real estate loans; instalment loans and commercial and industrial loans. Input prices: price of labour; price of physical capital; price of funds; deposit interest rate; purchased funds interest rate Control variables: number of branches, bank merger dummy variable and a time trend dummy variable.	Productivity declined after deregulation.
Elyasiani and Mehdian (1995)	DEA	Data for 1979 and 1986	To analyse effect of deregulation on banks' efficiency.	Outputs: investments, real estate loans, commercial and industrial loans and other loans. Inputs: deposits, capital and labour.	Technical efficiency declined by 3% after deregulation.
Evanoff (1999)	SFA	Sample of 164 US banks 1972-1978.	To evaluate whether industry regulations distort firm behaviour and, as a result, generate productive inefficiencies in mix of inputs used by banks.	Dependent variable: total cost. Outputs: commercial and industrial loans, instalment loans, real estate loans and investment. Input prices: price of labour, price of physical capital and price of funds.	Main findings: regulation distorted input prices and resulted in allocative inefficiencies.

(continued)

Table 3.3 Efficiency Studies in US Banking (continued)

Authors	Approach	Sample	Nature of Study	Variables	Main Findings
Wheelock and Wilson (1999)	DEA	Data 1984-1993	To measure change in productivity of US banks after deregulation.	Outputs: real estate loans, commercial and industrial loans, consumer loans, all other loans and demand deposits. Inputs: labour, physical capital and funds.	1984 -1993, all banks of different sizes experienced decline in technical efficiency. Also, productivity declined over same period.
Berger and Mester (2003)	TFA	Data from all US banks 1984, 1991 and 1997.	To examine how performance of banking industry has been affected by changes in technology, deregulation, competition and changes in business conditions.	Dependent variables: total costs (operating and interest expenses), net profit before tax. Outputs: consumer loans, business loans, real estate loans and investment. Input prices: price of labour, price of core deposits and price of funds. Output prices: price of consumer loans, price business loans, price of real-estate loans and price of securities. Control and environmental variables: off – balance sheet items, physical capital, equity, non-performing loans, real estate growth and concentration.	During 1991-1997, cost productivity in banking industry worsened while profit productivity improved substantially.
Alam (2001)	DEA	Sample of US banks whose assets exceed $500 million 1980-1989.	To test relationship between changes in productivity as result of deregulation and competition.	Outputs: investments, real estate loans, commercial and industrial loans, instalment loans. Inputs: equity, capital, labour, funds.	Productivity of banks rose as effect of deregulation.

(continued)

Table 3.3 Efficiency Studies in US Banking (continued)

Authors	Approach	Sample	Nature of Study	Variables	Main Findings
Berger and DeYoung (2001)	DFA	Sample of US banks 1993-1998.	To assess effects of geographic expansion as result of deregulation on banks' cost efficiency.	Dependent variables: total cost, net profit before tax. Outputs: consumer loans, business loans, real estate loans and securities. Input prices: price of labour, price of core deposits and price of funds. Control variables: off balance-sheet items, physical capital, equity, ratio of non-performing loans to total loans,	Geographic expansion has positive effects on cost and profit efficiency.
Mester (1993)	SFA	Data for 1051 banks 1991.	To measure cost efficiency for mutual and stock banks and to investigate factors affecting cost efficiency.	Dependent variable: total costs. Outputs: loans, investment. Prices of inputs: price of labour, price of physical capital and price of funds. Explanatory variables: non-performing loans, equity, ROA,	Stock banks less efficient than mutual banks[38]. Also, results indicate banks with high equity more cost efficient than banks with low equity.
Mester (1996)	SFA	Sample of 214 banks 1991-1992.	To see impact of quality and riskiness of bank output on estimated efficiency.	Dependent variable: total costs Outputs: real estate loans, commercial loans, individual loans. Input prices: price of labour, price of physical capital and price of funds. Control variables: non-performing loans and financial capital.	Quality and riskiness of banks' output has direct effect on estimated cost efficiency.
DeYoung and Nolle (1996)	SFA	Sample of 62 foreign-owned banks and 240 US-owned banks 1985-1990.	To compare efficiencies of foreign-owned banks and US-owned banks	Dependent variable: profit after tax Outputs: loans and investments. Input prices: price of loans, price of investment, price of funds, price of core deposits and price of labour. Control variables: equity, cash to asset, non-performing loans, ROA, ROE and assets.	US-owned banks more profit efficient than foreign-owned banks.

(continued)

[38]Stock banks owned by shareholders, mutual banks owned by depositors.

Table 3.3 Efficiency Studies in US Banking (continued)

Authors	Approach	Sample	Nature of Study	Variables	Main Findings
Kwan and Eisenbeis. (1996)	SFA	Semi-annual data for 254 bank holding companies 1986-1991, grouped into size - quartiles to allow for different production technologies for each size class.	To examine relationship between X-efficiency and risk taken by banks.	Dependent variable: total costs. Outputs: commercial loans, real estate loans, consumer loans, off balance-sheet items. Input prices: price of labour, price of physical capital, price of funds. Control variables: standard deviation of daily stock return, ratio of market value of equities to book value of total assets, ratio of equity to total assets, ratio of loan provision to total loans.	Average small banking firm found to be relatively less efficient than average large bank. Less efficient banking firms take more risks.
Berger and Mester (1997)	SFA, FDA	Sample of 6000 US banks 1990-1995.	To examine several possible sources of differences in measured efficiency. Differences in efficiency concepts (i.e. cost or profit efficiency), in measurement methods (i.e. SFA or DEA) and differences in potential correlates of efficiency that may explain some efficiency differences.	Dependent variables: total costs, net profit. Outputs: consumer loans, business loans, investments. Input prices: price of funds, price of core deposits, price of labour. Output prices: price of consumer loans, price of business loans, price of securities. Control and environmental variables: off balance-sheet items, equity, physical capital, non-performing loans, weighted average of non-performing loans for state.	Three efficiency measures (cost efficiency, profit efficiency and alternative profit efficiency) positively correlated to measure of performance (i.e. ratio analysis). Some market conditions (i.e. concentration) impact on efficiency scores.

(continued)

Table 3.3 **Efficiency Studies in US Banking (continued)**

Authors	Approach	Sample	Nature of Study	Variables	Main Findings
Mester (1997)	SFA	Sample of 6630 U.S banks 1991-1992.	To estimate bank efficiency for US banks by taking into consideration heterogeneity factors by formulating two cost functions: one for all banks in US and separate cost function for each District.	Dependent variable: total costs Outputs: real estate loans, commercial loans, individual loans. Input prices: price of labour, price of physical capital, price of funds. Control variables: non-performing loans, financial capital.	Results suggest it is important when studying X-efficiencies to account for differences across markets in which banks are operating
Bauer, Berger, Ferrier and Humphrey (1998)	SFA, TFA, FDA and DEA	683 U.S banks over 12 years 1977-1988.	To evaluate extent to which all four main approaches to estimating frontier efficiency (SFA, TFA, FDA, DEA) consistent with each other in many conditions and in other performance measures most useful for regulatory analysis.	Dependent variable: total costs. Outputs: real estate loans, instalment loans, commercial loans. Input prices: price of labour, price of physical capital, price of funds. Inputs: labour, physical capital, time deposits, purchased funds.	Parametric approach (i.e. SFA, TFA and FDA) tends to rank banks in same order, and identify mostly same banks as best practice and worst practice. DEA yields much lower average efficiencies, ranks banks differently and identifies best and worst banks differently from parametric methods. When performing regulatory analysis using many techniques, likely to be more helpful.
De Young and Hassan (1998)	SFA	Sample of US banks 1980-1994.	To compare profit efficiency of old and new established banks.	Dependent variable: profit before tax. Outputs: loans, transaction deposits, off-balance sheet items. Input prices: price of labour, price of physical capital, price of funds. Control variables: equity, concentration (i.e. Herfindahl Index), non-performing loans.	Results suggest new banks need nine years to reach old banks' profit efficiency levels.

(continued)

Table 3.3 Efficiency Studies in US Banking (continued)

Authors	Approach	Sample	Nature of Study	Variables	Main Findings
Evanoff and Ors (2002)	SFA	Sample of US banks 1984-1999.	To evaluate impact of actual and potential competition resulting from market entry mergers and acquisitions and reductions in entry barriers on banks' cost and profit efficiency.	Dependent variables: total costs, profit before tax. Input prices: price of labour, price of small deposits (core deposits), price of purchased funds. Outputs: securities, loans, leases. Output prices: price of securities, price of loans, price of leases loans. Control variables: physical capital, financial (equity) capital, dummy variable for entry, dummy variable for merger, concentration, age of bank, total assets.	Results consistent with economic theory. As result of merger, banks responded to increased competition by decreasing costs and increasing levels of efficiency.
Fare, Grosskopf and Weber (2004)	DEA	Random samples of 856 US banks 1990-1994.	To measure profit efficiency in banking, using newly developed technique (directional distance function) to determine effects of risk-based capital requirements on profit measurement and profit performance of US banks.	Inputs: labour, capital, deposits. Outputs: real estate loans, commercial and industrial loans, personal loans, transaction demand deposits. Input prices: price of labour, price of capital, price of deposits. Output prices: prices of real estate loans, prices of commercial loans, prices of personal loans, prices of transaction demand deposits. Control variable: equity.	Results show allocative inefficiency is larger source of profit loss than technical inefficiency and risk-based capital adequacy has significant negative impact on banks' allocative efficiency.

Table 3.4 Efficiency Studies in European Banking

Authors	Approach	Sample	Nature of Study	Variables	Main Findings
Vassiloglou and Giokas (1990)	DEA	Sample from 20 branches in Athens area 1987.	To measure relative efficiency of bank branches.	Inputs: number of hours per person, monetary value of stationery, square metres of branch floor space, number of computer terminals at each branch. Outputs: number of transactions processed at each branch.	11 branches out of 20 have technical inefficiencies. Average annual efficiency 0.91for all branches.
Berg, Førsund, Hjalmarsson and Suominen (1993)	DEA	Sample from 779 banks in Nordic countries 1990.	To investigate relative efficiency of banking industry in Finland, Norway and Sweden.	Inputs: labour and physical capital. Outputs: total loans, total deposits and number of branches.	Comparing best practice frontier highest efficiency in Sweden (0.89) lowest in Finland (0.58).
Drake and Howcroft (1994)	DEA	Sample of 190 branches of a major UK clearing bank 1991.	To measure technical efficiency of UK clearing branches, dichotomised to scale and pure technical efficiency.	Inputs: number of interview rooms, number of automatic tellers, floor area in square metres, management grade, clerical grade, stationery costs. Outputs: till transactions, lending products, deposit products, automated transfers, clearing items, ancillary business, and insurance business.	Results suggested that branches inefficient; 56% exhibited relative technical efficiency, 8% branches exhibited scale inefficiency, 16% exhibited pure technical efficiency.
Allen and Rai (1996)	SFA, DFA	Sample of 194 banks from 24 European countries 1988-1992.	To estimate cost function for international banks and to test input and output inefficiencies.	Dependent variables: total costs (total operating expense and interest expense). Outputs: loans, investment. Prices of Inputs: price of labour, price of fixed capital, price of fund.	DFA overestimated inefficiencies. Large banks experienced high inefficiency. No evidence scale and scope economies.
Lang and Welzel. (1996)	SFA	Sample of 757 German co-operative banks 1989-1992.	To investigate economy of scale, scope and cost efficiency in Germany banking.	Dependent variables: total costs (total operating expenses and interest expenses). Outputs: loans, inter-bank loans, investment, fees and commissions, revenue from sales of commodities. Prices of Inputs: price of labour, price of fixed capital and price of fund.	Evidence of moderate scale economies for all size classes, sign of economies of scale. Overall cost efficiency deviated from optimum.

(continued)

Table 3.4 Efficiency Studies in European Banking (continued)

Authors	Approach	Sample	Nature of Study	Variables	Main Findings
Altunbas, Goddard and Molyneux (1999)	SFA	Sample of 3779 banks from 15 European countries 1989-1996.	To investigate impact of technical change on costs of European banks.	Dependent variables: total costs (total operating expenses and interest expenses). Outputs: loans, investments, and off balance sheet items. Prices of Inputs: price of labour, price of fixed capital and price of funds.	Rate of reduction in costs due to technical change increased 1989-1996, large banks benefited more than small bank.
Vivas (1997)	TFA	Sample of 52 Spanish saving banks, 1986-1991.	To determine how deregulation has affected profit efficiency of Spanish saving banks.	Dependent variable: profit before tax. Outputs: loans, inter-bank loans, deposits. Prices of input: price of labour, price of physical capital, price of funds. Control variables: value of physical capital, number of branches.	Profit inefficiency of Spanish saving banks averaged 28%, falling by 40% 1986-1991.
Sheldon (1999)	DEA	Sample of 1783 EU commercial and saving banks 1993-1997.	To assess relative efficiency of banks across Europe, in order to address following questions, How large is cost differential among banks in Europe? What are sources of the cost differentials? What implications do results have for future structural change and policy?	Inputs: interest costs, personal costs, commission fees and trading expenses, other operating and administrative expenses, probability of insolvency. Outputs: net loans, other earning assets, off balance-sheet items and deposits.	Average frontier efficiency of European banks relatively low, 45% from cost perspective and 65% from profit prospective.
Altunbas, Evans and Molyneux (2001)	SFA, FDA	Sample of 7539 Germany banks 1989-1996.	To test differences in efficiency between different ownership structures (private, public, mutual) by estimating frontier for each type.	Dependent variables: total cost, (operating and interest expenses), net profit. Outputs: mortgage loans, public loans, other loans, investment, off balance -sheet items. Prices of inputs: price of labour, price of funds, and price of capital. Control variables: equity.	Little evidence to suggest privately-owned bank more efficient than mutual and public banks. Private and mutual banks appear to benefit from economies of scale.

(continued)

Table 3.4 Efficiency Studies in European Banking (continued)

Authors	Approach	Sample	Nature of Study	Variables	Main Findings
Altunbas, Gardener, Molyneux and Moore (2001)	SFA	Sample of 4104 banks from 15 European countries 1989-1997.	To establish literature on modelling cost characteristics of banking markets by applying flexible Fourier functional form to estimate scale economies and X-inefficiencies.	Dependent variables: total cost (operating and interest expenses). Outputs: loans, investment, and off balance-sheet items. Prices of input: price of labour, price of funds, and price of capital. Control variables: equity.	Scale economies widespread from smallest banks, those in ECU have assets size of 1-5 billion. Typically, scale economies are found to range between 5% and 7%, while X-inefficiency measures appear to be much larger, between 20% and 25%.
Vennet (2002)	SFA	Sample of 2375 European banks from 17 countries 1995-1996.	To analyse cost and profit efficiency of European financial conglomerates and universal banks.	Dependent variables: total cost (operating and interest expenses), net profit Outputs: loans and investment. Prices of inputs: price of labour, price of funds, price of capital. Control variable: equity.	Conglomerates more revenue efficient than specialised competitors and degree of both cost and profit efficiency higher in universal banks than in non-universal bank.
Griogorina (2002)	DEA	Sample of 1074 banks from 17 transition countries 1995-1998.	To consider differences in commercial bank efficiency across transition countries against wide array of variables describing macro environment and bank specific variables.	Inputs: labour, fixed assets, interest expenses. outputs: Set 1: revenues, net loans, liquid assets. Set 2: deposits, net loans, liquid assets. Control variables: number of employees, value of fixed assets, loans, deposits, equity, liquid assets, dummy for foreign banks, dummy for old banks, market share of each bank, GDP per capita, inflation.	Results indicated foreign banks more efficient than others.
Maudos, Pastor and Francisco (2002)	DEA	Sample of Spanish banks 1985-1996.	To investigate impact of specialisation on cost efficiency.	Outputs: loans, investments. Inputs: labour, fund, physical capital. Prices of inputs: price of labour, price of funds, price of capital.	Results suggested specialisation an important factor explaining differences between banks in term of efficiency. For example the saving banks are less efficient than commercial banks.

(continued)

Table 3.4 Efficiency Studies in European Banking (continued)

Authors	Approach	Sample	Nature of Study	Variables	Main Findings
Casu and Molyneux (2003)	DEA	Sample of 530 banks from France, Germany, Italy, Spain and U.K 1993-1997	To investigate whether productive efficiency of European banking has improved as result of the creation of single internal market and factors that have impacted on efficiency.	Inputs: total costs, total deposits. Outputs: loans and other earning assets Control variables: dummy for countries, equity to assets, ROE, dummy for commercial banks, dummy if bank listed on stock exchange.	Results suggested since EU single market programme, small improvement in bank efficiency. In addition, ROE positively related to bank efficiency.
Weill (2004)	DEA, SFA, FDA	Unconsolidated accounting data for 688 banks in France, Germany, Italy, Spain, Switzerland.	To investigate consistency of efficient frontier methods.	Outputs: loans, investment assets Inputs: personnel expenses, other non-interest expenses, interest paid. Input prices: labour, physical capital and borrowed funds.	Main findings tended to support lack of robustness of frontier approach (i.e. the ranking order between DEA and SFA is very low).
Tortosa-Ausina (2004)	DEA	Sample of Spanish banks 1995-1998.	To investigate whether specialisation, ownership type, size bias bank efficiency.	Outputs: loans, investments, off balance-sheet items. Inputs: labour, funds, physical capital. Prices of inputs: labour, funds, and capital.	Inefficiencies large and seemed to persist, despite competitive forces being unrestrained. Ownership type, firm size and specialisation did not have absolute effect on efficiency.
Bos and Kool (2006)	SFA	Sample of 401 small co-operative banks in Netherlands 1998 and 1999.	To estimate standard stochastic profit and cost frontiers using exogenous market determinant input prices in efficiency estimation.	Dependent variables: total costs, profit before tax. Outputs: retail loans, wholesale loans, mortgage loans, loans' provisions. Prices of inputs: labour, funds, capital, equity, public relations.	Use of exogenous input prices, rather than endogenous particularly important for cost frontiers as spread in cost inefficiencies becomes larger and more plausible.
Casu and Girardone (2006)	DEA	Data from Bank Scope for 11000 observations from 15 European countries 1997-2003.	To test relationship between competition, concentration and efficiency in European banking market.	Inputs: total costs. Outputs: loans, other earning assets.	Findings seemed to suggest most efficient banking systems also most competitive. Relationship between competition and efficiency not straightforward: increased competition has forced banks to become more efficient but increased efficiency does not seem to be fostering more competition in EU banking system.

(continued)

Table 3.4 Efficiency Studies in European Banking (continued)

Authors	Approach	Sample	Nature of Study	Variables	Main Findings
Fiorentino, Karmann and Koetter (2006)	SFA, DEA	Data from Deutsche Bundesbank 1993-2004.	To compare efficiency scores obtained from DEA and SFA.	Dependent variable: total costs (operating and interest costs). Outputs: inter-bank loans, commercial loans securities. Inputs: fixed assets, employees, funds. Input prices: fixed assets, labour, funds.	Results showed very low consistency between SFA and DEA measures, especially when applied to entire panel sample. Mean of cost efficiency according to SFA substantially higher when compared to DEA.
Bos, Koetter, Kolari and Kool (2009)	SFA	Sample of German cooperative and saving banks 1993-2005.	To investigate impact of heterogeneity among banks regarding estimated cost and profit efficiency, by one-stage analysis.	Dependent variables: total costs, net profit. Outputs: inter-bank loans, customers' loans, and investment. Inputs prices: funds, labour, capital. Control variables: equity, banks type, regional location, size.	Cost and profit efficiency scores underestimated when not allowing for heterogeneity among banks.

Table 3.5 Efficiency Studies in Other Countries and Developing Countries Banking

Authors	Approach	Sample	Nature of Study	Variables	Main Findings
Zaim (1995)	DEA	Sample of 42 banks 1981 and 56 banks 1990	Impact of liberalisation policies on efficiency of Turkish banks.	Outputs: demand deposits, time deposits, loans. Inputs: number of employee, interest expenses, depreciation, expenditure on furniture.	Turkish banks experienced improved efficiency in more liberalised banking environment. In addition, state banks more efficient than private banks.
Hardy and di Patti (2001)	FDA	Sample of 33 Pakistani banks 1981-1997.	To investigate effects of financial reforms on the Pakistani banks' efficiency.	Dependent variables: profit/total assets, cost/total assets, revenue/total assets. Outputs: earning assets/total assets. Output price: interest receipt/ earning assets. Input prices: interest costs/earning liabilities, other costs/earning liabilities. Control and environmental variables: capital and reserves/total assets, inter bank borrowing/ deposits, growth in GDP.	Main effect of financial reform was increase in both revenue and cost. Public sector and privatised banks made progress in improving cost efficiency and relative profitability improved.
Isik and Hassan (2003)	DEA	Data for all Turkish banks 1988 -1996.	To explore impact of ownership structure, market structure, corporate control and other bank traits on bank efficiency.	Outputs: loans, off balance-sheet items, other earning assets. Inputs: labour, capital and funds.	Public banks and foreign banks were more efficient than private ones, in terms of cost and technical efficiency. Also, bank size did not seem to be strongly correlated with cost efficiency. Banks' performance improved after implementation of financial deregulation.
Sturm and Williams (2004)	DEA, SFA	Data for 39 Australian banks 1988-2001.	To investigate impact of foreign bank entry on banking efficiency in Australia.	Inputs (model 1): employee numbers, deposits and borrowed funds, equity capital. Outputs (model 2): loan advances and other receivables, off balance-sheet activity measured as commitments and contingent liabilities. Inputs (model 2): interest expenses, non-interest expenses. Outputs (model 2): net interest income, non-interest income	Foreign banks more efficient than domestic banks. Entry of foreign banks contributed positively to increasing efficiency levels of Australian banks.

(continued)

Table 3.5 Efficiency Studies in Other Countries and Developing Countries Banking (continued)

Authors	Approach	Sample	Nature of Study	Variables	Main Findings
Hao, Hunter and Won Keun Yang (2001)	SFA	Sample of 19 private Korean banks 1985-1995.	To investigate impact of deregulation on banks' efficiency and factors impacting on efficiency scores. Second stage analysis used.	Dependent variable: total costs. Outputs: loans and securities, demand deposits, and fee incomes. Inputs prices: price of fund, price of labour and price of capital. Control variables: equity, age of banks, total assets, growth rate of total assets over the previous 12 months, ratio of salary to total assets; the ratio of total employees to total assets, ratio of demand deposit to total deposits, non-interest income over operating profits.	Average efficiency scores for Korean banks 87 %. No impact of financial deregulation on cost efficiency. Banks with high rates of growth more efficient, and bank efficiency positively correlated with foreign equity ownership.
Rao (2005)	SFA	Data from 37 UAE 1998-2001.	To investigate cost efficiency of UAE banks, and to show whether local banks are less or more efficient than foreign banks. Also, to determine factors that impact on cost efficiency by employing second stage analysis.	Dependent variable: total cost (operating and expenses costs). Outputs: investments, loans and off-balance sheet items. Input prices: price of funds and price of labour. Control variables: type of banks (foreign, domestic), year dummies, default risk (ratio of loan loss provision/total loans), liquidity risk (ratio of cash and dues from banks/total assets), capital risk (ratio of equity to capital), ratio of retail deposits to total deposits, and ratio of net loans to total earning assets.	Cost inefficiencies ranging 20%-25%. Local banks more cost efficient than foreign banks.
Lin (2005)	SFA	Sample of 46 Taiwanese commercial banks 1997-1999.	To evaluate effects of bank mergers on bank efficiency.	Dependent variable: total cost (operating and expenses costs). Output: loans. Input prices: price of funds, price of labour and price of capital. Control variables: non-performing loans ratio, loan to deposit ratio, total assets and dummy variable for merger.	Banks' cost efficiency improved if bank mergers happened between banks with different cultural backgrounds. However, if mergers occurred between homogeneous banks, little improvement in cost efficiency.

(continued)

Table 3.5 Efficiency Studies in Other Countries and Developing Countries Banking (continued)

Authors	Approach	Sample	Nature of Study	Variables	Main Findings
Williams and Nguyen (2005)	SFA	Sample of 231 commercial banks from South-East Asia 1990-2003.	To investigate impact of deregulation on alternative profit efficiency and to investigate impact of control and environmental variables on estimated profit efficiency, using one-stage analysis.	Dependent variable: net profit. Outputs: loans, other earning assets, and non-interest income. Price of inputs: price of funds, price of labour and price of capital. Control and environmental variables: equity, credit risk (loan reserve/loans), market risk (interbank loans/interbank loans and securities), liquidity risk (gross loans/customer deposits), capital risk (equity/assets), GDP per capita, population density (population per km), deposit density (deposits per km).	Results indicated bank privatisation increased banks' performance. Also, results indicated foreign banks more efficient than domestic banks.
Havrylchyk (2006)	DEA	Data for all Polish banks for 1997- 2001.	To investigate efficiency of Polish banks and role of foreign banks in Poland.	Outputs: Loans, treasury bonds and off balance sheet items. Inputs: deposits, fixed assets and labour. Prices of inputs: price of deposits, price of fixed assets, price of labour. Control variables: dummy variable for foreign bank, dummy variable for state banks, dummy variable for listing banks, dummy variable for home country of foreign banks, growth in total assets, non-performing loans, loan to total assets and variation on ROA.	Foreign banks more efficient than domestic banks.
Ataullah, Cockerill and Le Hang (2004)	DEA	Data for Pakistani and Indian banks for 1988 – 1998.	Test hypothesis regarding possibility of relationship between economic reforms and bank efficiency. Relationship between measured efficiency, bank specific factors, environmental factors.	Inputs: operating and interest expenses. Outputs: loans and advances, investment.	Improvement in technical efficiency of banks, especially of foreign banks, after economic reform.

(continued)

Table 3.5 **Efficiency Studies in Other Countries and Developing Countries Banking (continued)**

Authors	Approach	Sample	Nature of Study	Variables	Main Findings
Kwan (2006)	SFA	Data from 59 Hong Kong banks1992-1999.	To investigate cost efficiency of multi-branch operation in Hong Kong.	Dependent variable: total cost (operating and expenses costs). Input prices: price of funds, price of labour, price of capital. Outputs: loans to finance imports, exports, re-exports, merchandising trade, loans for non-trade-related financing, other earning assets. Control variables: bank size, deposit-to-asset ratio, ratio of trade-related loans to total assets, ratio of non-trade-related loans to total assets, ratio of loan-loss provision to total loans, ratio of off balance-sheet activities to total assets, loan growth.	Average X-inefficiency in Hong Kong bank about 16-30%. Large banks less efficient than smaller bank.
Drake, Hall, and Simper (2006)	DEA	Data from sample of Hong Kong banks 1995-2002.	To study effects of impact of macroeconomic factors on levels of efficiency.	Outputs: net interest income, net commissions, totals other income. Inputs: employee expenses, other non-interest expenses, and loan loss provisions. Macroeconomic variables: private consumption expenditure, government expenditure, net export of goods, net export of services, discount window base rate, unemployment levels, expenditure in housing and current account balance. Regulatory variables: dummy variables for some years.	Macroeconomic variables have significant impacts on efficiency levels of Hong Kong banks. For example the South East Asian financial crisis, affect negatively on efficiency score.
Kraft, Hofler and Payne (2006)	SFA	Data from Croatian banks 1994-2000.	To investigate effects of privatisation and foreign banks' entry on efficiency levels of local banks.	Dependent variable: total cost (operating and expenses costs). Input prices: price of funds, price of labour and price of capital. Outputs: loans to enterprise, loans to household, deposits to enterprise. Control variables: total assets, total capital, and dummy variable for private banks, dummy variable for new banks, and dummy variable for foreign banks.	Foreign banks proved more efficient than local banks. Liberalisation did not improve efficiency levels for local banks.

(continued)

Table 3.5 Efficiency Studies in Other Countries and Developing Countries Banking (continued)

Authors	Approach	Sample	Nature of Study	Variables	Main Findings
Cumhur Erdem and Meziyat Sema Erdem (2008)	DEA	Data from Turkish banks whose stocks are traded in Turkish financial market 1998-2004.	To investigate impact of banking crises in 2000 and 2001, on level of banks' efficiency.	Inputs: labour, physical capital and funds. Outputs: profit before tax.	Average banks' efficiency decreased from 0.71 in 1999 to 0.54 in 2001 and then started to increase, indicating financial crises affected efficiency scores of Turkish banks.

Chapter 4 The Jordanian Banking Sector 1993-2006

4.1 Introduction

A higher degree of competition and efficiency in the banking system can contribute to greater financial stability, product innovation and easier access to financial services, which in turn can improve the prospect of economic growth (Molyneux et al., 1996). The concern is that government intervention within a banking system is seen as a main factor for poor performance and low efficiency levels within banks (Kumbhakar and Sarkar, 2003). In this respect, it is important to identify the various reforms and measures that have taken place in Jordan to promote competition and efficiency in the banking system. The main purpose of this chapter, therefore, is to provide an overview of the banking system in Jordan and the main measures put in place to deregulate it. The main characteristics and evolution of the system will also be outlined.

Section 4.2 gives a brief overview of the Jordanian economy. Section 4.3 presents an overview of the Jordanian banking system and the main measures taken to deregulate it. Section 4.4 reviews the structure of Jordanian banking in terms of ownership structure and different kinds of banks. This section also shows how the balance sheet and income statement structure of banks has changed during 1993-2006 as a result of the deregulation. Section 4.5 shows the performance of the Jordanian banks based on ratio analysis. Section 4.6 outlines the development of competition in the Jordanian banking market.

4.2 Brief Overview of the Jordanian Economy

Jordan is a low-middle-income country with a nominal per capita income estimated at about $2,515 in 2006 (World Bank, 2006) with a relatively small economy with abundant skilled human resources and limited natural resources (Alissa, 2007). To maintain its social and economic well-being, Jordan relies heavily on external resources such as foreign aid, remittance of Jordanians working abroad and external loans (Alissa, 2007).

McDermott (1996) pointed out that historically Jordan's economic performance was robust from 1970 to the mid-1980s as a result of flow of aid from rich Arab countries and of remittances of Jordanians working in these countries. The real gross domestic product (GDP) rose by 9.5 per cent a year in the years 1976-1980. However, with the economic slowdown in the Gulf as a result of the decrease of international oil prices after 1983, the availability of external resources to Jordan became more limited, demand for Jordanian products and workers in the Gulf declined and remittances from abroad became more volatile and dropped by 38 per cent from more than $1.2 billion in 1984 to around $900 million in 1988 (Alissa, 2007). Given these changes, Jordan faced mounting balance-of-payments problems, increased unemployment caused by the lack of job opportunities in the Gulf and increased external debt. Moreover, in 1989 the Jordanian economy faced a major crisis when the Jordanian Dinar (JOD) suffered a major devaluation (i.e. the JOD lost 51% of its value against the US Dollar), total government debt reached 197 per cent of GDP and the country's reserves of foreign currency declined sharply (Isik et al., 2004).

The Jordanian economy was in the process of collapse and, in 1989, real GDP shrank by 10.7 per cent, the inflation rate increased to 25.7 per cent and the budget deficit, excluding grants, reached 24 per cent of GDP (Alissa, 2007). As a result, since 1989, Jordan has been implementing, with the aid of the International Monetary Fund (IMF) and the World Bank (WB) strong stabilisation and structural reform programmes. The major goals of these programmes were to strengthen state revenues while reducing state expenditures by implementing long-term policies such as privatising state industries, introducing new taxes, freezing public sector salaries and liberalising the financial system (Isik et al., 2004). Table 4.1 shows key macroeconomic indicators of Jordan from 1989 to 2006. As the table indicates, as a result of implementing the structural reform programmes, a number of important areas have been satisfying. Real GDP grew from a negative value in 1989 to a positive value after 1991. The GDP growth rate reached 14 per cent in 1992 and in 1993-2006 was 5.1 per cent. The percentage of external debt to GDP decreased from 197 per cent in 1989 to 62 per cent in 2006. Excluding grants, the budget and current account deficits were reduced from over 25.66 per cent of GDP at the beginning of the programme (i.e. 1989) to 3.81 per cent in 1992. However, the deficits in current account began to rise after 1993 to reach 18.04 per cent in 2003. This increase could be attributed to the slowdown of growth in internal revenues. Foreign currency reserves grew from 1055 MJOD in 1993 to 4779 MJOD in 2006. This could be attributed to many reasons such as the increase in Jordan's exports and the removal of restrictions on the foreign exchange system, as will be explained later when discussing deregulation measures. The foreign direct investment (FDI) inflows to the country increased rapidly after 1997 as a result of removing the restriction on foreign ownership, as will be discussed later. Moreover, inflation was reduced from 25.6 per cent in 1989 to an average of 2.9 per cent between 1993-2006.

Table 4.1 Macroeconomic's Indicators of Jordan (1989-2006)

Year	GDP constant price in MJOD[1]	GDP growth rate (%)	External debt in MJOD[2]	External debt as % of GDP	Deficits as % of GDP[3]	Foreign Reserve in MJOD[4]	Foreign direct investment net flow (MJOD)[5]	Inflation in percentage	Bank Assets as % of GDP
1989	3428.70	-10.70	6745.30	197	24	NA	-0.71	25.60	110.25
1990	3419.30	-0.27	5765.30	169	11.00	NA	26.94	16.20	119.62
1991	3474.30	1.61	4973.90	143	11.67	NA	-8.51	8.20	161.16
1992	3972.80	14.35	4577.60	115	3.81	NA	29.07	4.00	158.86
1993	4151.10	4.50	3640.20	88	4.89	NA	-24.11	3.20	144.03
1994	4358.10	4.99	5253.30	121	6.69	1055.80	2.13	3.60	153.25
1995	4627.70	6.19	5186.50	112	6.26	1224.60	9.22	2.20	162.63
1996	4724.30	2.09	5056.70	107	7.57	1442.30	11.34	6.60	165.61
1997	4880.50	3.31	5348.80	110	11.75	2151.80	255.95	3.00	176.54
1998	5027.60	3.01	5391.80	107	12.20	1681.70	219.79	3.10	187.47
1999	5198.00	3.39	5350.40	103	10.43	2162.00	112.02	0.60	200.77
2000	5418.70	4.25	4969.80	92	10.98	2406.60	577.84	0.70	211.75
2001	5704.20	5.27	5043.50	88	11.53	2280.40	127.62	1.80	219.87
2002	6034.10	5.78	5510.10	91	12.46	2953.00	86.50	1.80	219.17
2003	6286.30	4.18	5333.70	85	18.04	4005.70	314.09	1.60	219.64
2004	6822.80	8.53	4998.10	73	15.14	4059.00	578.54	3.40	235.83
2005	7378.60	8.15	5164.30	70	13.24	4082.00	1257.77	3.50	262.79
2006	7967.00	7.97	4911.80	62	9.39	4779.00	2282.27	6.25	282.70

[1] Real in million of Jordanian dinar MJOD and the JOD equals 1.41 US dollars.
[2] Values in nominal terms.
[3] Deficits equal revenues excluding external and internal debt minus expenditures in nominal terms.
[4] Values in nominal terms.
[5] Values in nominal terms.
Source: Yearly Statistical Series, CBJ (2008).

4.3 Overview of the Banking System in Jordan 1993-2006

The introduction of the banking system into Jordan dates back to 1925 when the British Ottoman Bank opened in Amman and acted as fiscal agent to the government in the absence of a central bank. The first national bank established in Jordan was the Arab Bank. This bank was established in Jerusalem in 1930 and moved its headquarters to

Amman after the 1948 war between the Arabs and Israelis (Miani and Daradkah, 2008). Up to forty years ago, banking in Jordan was insignificant. Some foreign banks had branches in order to facilitate trade finance and to serve foreign workers in the region but local banks were scarce and their role in the economy was very limited. Since 1970 and the discovery of oil in the Middle East, Jordan has undergone a process of significant economic change: during the 70's and 80's, the banking sector doubled its loans and deposits. Also, during this period, the number of banks doubled as the government identified banking services as a key player in its economic development policy (Saleh and Zeitun, 2006). The number of banks before 1970 was 8, 4 of these were foreign. During the 1970's, 6 new banks were established in Jordan: 5 national and 1 foreign. During the 1980's and 1990's, another 6 banks were established in Jordan, all of them national banks. During the 2000's, 3 foreign banks opened in Jordan.

The banking and financial system products and services formulated of 17 per cent of Jordan's GDP and the value of Jordanian banks' assets exceeded GDP for all years 1993-2006. This gives an indication of the crucial role that the banking system is playing in the economic development and growth of Jordan.

There were 23 banks operating in Jordan at the end of 2006, 8 of which were foreign and 2 Islamic. Licensed banks operate 456 branches in Jordan and 125 outside the country, 61 of which are in Palestinian territories (Table 4.2 shows a profile of Jordanian banks).

Table 4.2 Profiles of Jordanian Banks

Bank Name	Year of Foundation	Financial Capital (MJOD)	Ownership Structure	Type of Bank	Branches Local	Branches Abroad
Bank of Jordan	1960	86	Jordanian 78% Foreigners 22%	Commercial	44	7
Jordan National Bank	1956	110	Jordanian 76 % Foreigners 23%	Commercial	42	14
HSBC	1949	14	Foreigners 100%	Commercial	2	-
Rafdien	1957	10	Foreigners 100%	Commercial	1	-
Arab Bank	1930	356	Jordanian 43% Foreigners 57%	Commercial	82	96
Arab Egyptian Bank	1951	20	Foreigners 100%	Commercial	8	-
Cairo Amman Bank	1960	67.5	Jordanian 77% Foreigners 23%	Commercial	36	16
Standard Chartered	1969	13	Foreigners 100%	Commercial	8	-
City Bank	1974	23.5	Foreigners 100%	Commercial	2	-
Jordan Kuwait Bank	1977	75	Jordanian 42.2% Foreigners 58%	Commercial	34	3
Jordan Commercial Bank (Gulf Bank)	1978	57.5	Jordanian 74% Foreigners 26%	Commercial	24	3
Arab Investment Bank	1978	44	Jordanian 76% Foreigners 22%	Investment	8	1
Jordan Islamic Bank	1979	64.1	Jordanian 38% Foreigners 62%	Islamic	54	0
Housing Bank	1974	250	Jordanian 22% Foreigners 76%	Commercial	96	7
Jordan Bank for Investment and Finance	1989	33	Jordanian 89 % Foreigners 11%	Investment	7	0
ABC	1989	44.8	Jordanian 11 % Foreigners 89%	Commercial	12	0
Union Bank	1991	55	Jordanian 66 % Foreigners 34%	Investment	12	1
Societe General	1993	27	Jordanian 42% Foreigners 54%	Commercial	16	-
Capital Bank	1996	116	Jordanian 80% Foreigners 20%	Investment	5	-
International Arabic Islamic Bank	1998	40	Jordanian 100%	Islamic	11	0
National Bank of Kuwait	2004	50	Foreigners 100%	Commercial	1	-
Audi Bank	2004	20	Foreigners 100%	Commercial	7	-
Blom Bank	2004	20	Foreigners 100%	Commercial	3	-

Source: Central Bank of Jordan (2007)

The banking system is regulated by the Central Bank of Jordan (CBJ), the governmental monetary institution dominating the banking and monetary system of Jordan. The CBJ, established in 1964, is the only authority responsible for controlling monetary policy and the banking system in Jordan: it is managed by a Board of Directors consisting of 8 people, 3 of whom are senior managers within the CBJ. The boards of the CBJ are appointed by the Ministry Council. According to Standard and Poor's (2007), the CBJ is regarded as one of the most conservative and proactive regulators in the Middle East. The CBJ periodically updates commercial bank regulations, in order to ensure that the interests of the public are protected. The CBJ regulations aim to:

- Enhance banks' risk-monitoring systems through enhancing the role of risk management at each bank.

- Improve bank reporting and data warehousing through adopting the international accounting standards (e.g. IAS 39).
- Provide incentives for stronger compliance and governance practices.
- Improve bank risk management practice.
- Provide sound international supervision practice.

During the past ten years, the CBJ has revised some of its regulations and has adopted the Basel guidelines for effective supervision of corporate governance, cross-border supervision, internal control, risk management and Basel II[39]. The development of monetary policy in Jordan may be divided into two stages: the first (1964-1990) and second (1991-present). In the first stage, the CBJ used direct and traditional monetary tools (e.g. fixing interest rates, reserve requirement ratio) to control the operation of the banking system (Miani and Daradkah, 2008). The Jordanian banking industry served as an agent of the government, channelling investment funds to selected sectors under the country's economic development policy (e.g. banks were required to invest 8% of their deposits in government bills and bonds and to invest at least 15% of their capital in the public and mixed sectors), whilst imposing many requirements and restrictions on banking activities (Maghyereh, 2002). The CBJ implemented a direct management control to determine the size, cost and direction of credit facilities and restructure the financial portfolio of the banks. For example, the CBJ determined lending limits for banks, set a ceiling on interest rates for loans and deposits, restricted entry into the Jordanian banking market, imposed high reserve requirement ratios and tight restrictions on foreign exchange transactions (Karasneh et al., 1997). As mentioned earlier, in 1989 Jordan faced a crisis and as a result the banking sector suffered from problems such as an increase in the ratio of non-performing loans. This subsequently led to serious consequences for the banking industry and the collapse of many Jordanian Banks (e.g. Petra Bank, Islamic National Bank, Amman Bank) (Al-Jarrah, 2002).

The second stage (1991-present) was influenced by the crisis of 1989 and, as mentioned earlier, the Jordanian Government started to co-operate with the International Monetary Fund (IMF) and the World Bank (WB) in order to develop a structural reform

[39] Basel II takes a three-pillar approach to regulatory capital measurement and capital standards: Pillar 1 (minimum capital requirements), Pillar 2 (supervisory process) and Pillar 3 (market discipline and disclosures) (for more detail, see Basel, 2004).

programme. The liberalisation of the banking system in Jordan was a part of this and was aimed to improve the structure and efficiency of Jordanian banks (Crane et al., 2003). In the early 1990's, the CBJ initiated a series of financial sector reforms. Table 4.3 shows the main deregulation process initiated by the CBJ over the period 1990-2006. In February 1991, with the removal of interest rates ceilings on deposits and credit the CBJ adopted a floating policy in respect of both debit and credit market interest rates. The CBJ now lets market forces (supply and demand) determine the market interest rates by providing signals through open market operations[40] and the first open market instrument used by the CBJ, in 1991, was treasury bill auctions (CBJ, 2004). This aimed to bring about the wider role of market forces to influence treasury bill rates and facilitate the use of the indirect techniques (e.g. certificate of deposits) of monetary control.

In 1993, the CBJ introduced another indirect instrument by issuing its own certificates of deposit (CD) to mop up excess liquidity within banks (CBJ, 2004): the issuing of the CD allowed banks to invest their excess liquidity and get extra returns. In addition, the CBJ exempted banks from paying reserve requirements on purchased CDs and offered to re-purchase them from banks. Since 1993, in an effort to motivate the banks to produce a variety of products and services (e.g. foreign-investment products) and to manage their risks, the CBJ has allowed banks to manage foreign-investment portfolios on the basis of margin trading for non-resident customers[41] (in 1996, the CBJ allowed banks to offer this service to resident customers). The CBJ has also allowed banks to use market derivatives, such as option and future contracts, to hedge their positions on foreign currency. Before 1995, banks were required to seek CBJ approval for any loans exceeding 100,000 JOD and this restriction aimed to determine the scope of credit facilities offered by banks which meant that they did not have the potential to expand their loans and thus enhance their revenue. In 1995, the CBJ gave bank management greater autonomy to grant loans without prior approval of the CBJ but with some restrictions (see Table 4.4), and in 1996 the CBJ took greater steps to deregulate the banking system. Mandatory reserve requirements on foreign currency deposits fell from 35 per cent to 14 per cent and banks were allowed to use 20 per cent of the reserve

[40] Buying and selling government securities by the CBJ, such as treasury bills and certificates of deposits to control the money supply and give signals about the level of interest rates.
[41] Non-resident customers represent those having accounts in foreign currency and whose sources of funds in these accounts are outside Jordan.

requirements in the inter-bank market. This allowed banks more funds to invest in loans and other investments, which in turn could lead to an improvement in the banks' revenue. In November 1996, the CBJ began to publish the weighted average interest rates of inter-bank loans and this disclosure helped banks to increase their effectiveness in managing assets and liabilities. The year 1997 saw the allowing of foreigners to invest over 50 per cent of their capital in Jordanian banks and, in March 1997, the maximum limit of 49 per cent regarding direct foreign investment and stock purchase was eliminated (Isik et al., 2004). This led to the raising of foreign shares in Jordanian banks from 31 per cent in 1996 to 45 per cent in 1997, increasing to 55 per cent in 2006. Furthermore, the CBJ removed all restrictions on foreign exchange systems in 1997 (CBJ, 2004). The main measures taken in 1997 included:

- Opening of non-resident accounts in Jordanian dinars and or / foreign currency;
- Allowing resident account holders to maintain an account in foreign currencies of any amount;
- Transferring the value of imports to foreign beneficiaries without CBJ approval;
- Removing all restrictions on money transferred out of Jordan;
- Reducing all reserve requirements on deposits in foreign currency and JOD reduced from 14 per cent to 12 per cent. This gradual reduction was designed to lower the cost of funds for banks, increase banking sector liquidity and induce banks to lower their lending rates and expand credit facilities.

To promote the development of the money market, the CBJ introduced another indirect instrument in February 1998, by opening an overnight deposit facility. The use of this facility gave the banks an opportunity to employ their excess liquidity and earn extra income, which in turn could help the banks to enhance their profits. In addition, the facility would increase the effectiveness of the monetary policy in directing interest rates towards their market rate (CBJ, 2004). Additionally, to promote competition, a licence was given to two new local banks operating in Jordan, one of which was an Islamic bank. In 2000, the CBJ deregulation process was continued through the following measures:

- Greater autonomy was given to bank management in deciding the price of commission and other banking fees. In addition, the CBJ commission regarding money transferred out of Jordan was cancelled;

- CBJ allowed banks to own insurance companies (full ownership);
- CBJ adopted the International Accounting Standard (IAS) (IAS 39), a unified disclosure for all Jordanian banks, which would help in increasing competition between them. IAS 39 allows banks to recognise unrealised profits from financial instruments (e.g. trading and held-to-maturity investments). Allowing banks to recognise unrealised profits means that banks can increase their profits;
- CBJ allowed banks to take open positions in foreign currency (short or long-position) for the purpose of trading;
- In an effort by the CBJ to promote competition in the banking market, banks were required to publish their prime lending rate.

In 2000, the CBJ introduced the new banking law that has widened the scope of banking services in Jordan towards a 'universal banking' concept. This new law has impacted on many banking issues, such as protecting deposits (i.e. establishing the Deposit Insurance Company), protection against loan concentration, and it also outlines advice on new banking practices (e.g. e-commerce and e-banking) (CBJ, 2000).

In 2003, in an effort to promote and enhance competition within the Jordanian banking industry, the CBJ allowed three branches of foreign banks to operate in Jordan. These belong to a large financial institution in the Middle-East area and have a strong financial position and good risk management practices and the CBJ hoped that their introduction would help in promoting competition in the Jordanian banking market and in motivating existing banks to operate more efficiently, in order to be able to compete with the new banks. The CBJ also reduced the general provision[42] on loans from 2 per cent to 1 per cent.

[42] General provisions or general loan-loss reserves are created against the possibility of future losses of loans. This provision is different from specific provision created against overdue loans.

Table 4.3 Deregulation Measures in Jordan 1993-2006

Year	Deregulation Measures
1991	Interest rates fully liberalised. In February 1991, CBJ adopted floating policy with respect to both debit and credit market interest rates. Consequently, market forces (supply & demand) now determine market interest rates in Jordan. CBJ provides signals regarding interest rates to *licensed banks through its indirect monetary policy, using different instruments.*
1991	Treasury bill auctions introduced, in order to bring about wider role for market forces to influence treasury bill rates and to facilitate use of indirect techniques of monetary control.
1993	CBJ issued its own certificate of deposits (CD) to mop up excess liquidity as indirect technique of monetary control. In addition, CBJ exempted banks from paying reserve requirements on purchased CD's. At same time, CBJ offered to re-purchase CDs from banks.
1993	CBJ allowed banks to manage foreign investment portfolios on basis of margin trading. In addition, CBJ permitted banks to use market derivatives, such as option and future contracts, to hedge their positions on foreign currency.
1995	Ceilings on credit extended by banks eliminated.
1996	Foreign exchange system partially liberalised through: (1) mandatory reserve requirement for foreign currency deposits reduced from 35 per cent to 14 per cent, (2) banks permitted to use 20 per cent of reserves in their inter-bank market.
1996	The CBJ permitted swap operations in foreign exchange, in order to enhance the efficiency of the foreign exchange market.
1996	Weighted average of interest rates of inter-bank loans announced by the CBJ.
1997	Maximum limit of 49% regarding size of FDI in Jordanian Banks eliminated.
1997	CBJ fully removed all restrictions from foreign exchange system. Main measures taken: - Non-resident accounts could be opened in Jordanian dinars and or / foreign currency. - Resident account holders could maintain account holding any amount of foreign currency. - Value of imports to foreign beneficiaries no longer subject to CBJ approval. - Removal of restrictions on transferring money out of Jordan.
1997	On-site and off-site departments of CBJ merged into one department - supervision department.
1998	CBJ introduced overnight deposit facility. Banks could use this to manage excess liquidity better.
2000	Greater autonomy given to bank management in deciding price of commission and other banking services. In addition, commission on transfer of the money out of Jordan cancelled by CBJ.
2000	CBJ allowed banks to own insuring subsidiary companies (full ownership).
2000	CBJ adopted International Accounting Standard (IAS 39) which unified disclosure for all Jordanian banks. In addition to this, IAS 39 allowed banks to recognise unrealised profit from financial instruments (e.g. trading and held-to-maturity investments)
2000	CBJ allowed banks to take open positions in foreign currency. Moreover, allowed banks to take position on derivatives, for purposes of trading.
2000	To enhance competition between banks, CBJ imposed on them publication of periodical prime lending rate.
2000	CBJ issued new banking law widening scope of banking services in Jordan towards 'universal banking'[43] concept. Law also emphasised many issues to help in strengthening banks' soundness, such as Corporate Governance.
2000	Deposit Insurance Company established.
2001	CBJ exempted CDs issued in Jordanian Dinars by banks from reserve requirements.
2003	CBJ allowed additional three foreign banks to operate in Jordanian banking market.
2003	CBJ reduced general provision on loans from 2 per cent to 1 per cent.

Source: CBJ (2004)

To sum up, the deregulation process undertaken by the CBJ can be divided into three stages:

[43] Banking that includes investment services, in addition to services related to savings and loans (Gardner and Molyneux, 1993).

- The first stage (1993-1996) is characterised by the deregulation on the interest rates. During this period the ceiling on interest rates were eliminated and the CBJ provides signals regarding interest rates to banks through its indirect monetary policy, using different instruments such as treasury bills and CDs.
- The second stage (1997-2001) is characterised by the removal of restriction on the scope on banks operations. During this period the CBJ allowed for banks to produce more products and to offer different services such as foreign exchange transactions.
- The third stage (2002-2006) is characterised by opening the Jordanian banking market to the three new foreign banks. Moreover, during this period the CBJ worked to strengthen its regulations on corporate governance and the issues relating to risk management.

The main aims of the CBJ in liberalising the banking system were to promote a diversified, efficient and competitive financial system in order to improve resource allocation and financial viability and operational flexibility (Crane et al., 2003). The government and the CBJ hoped that productivity, profitability, lower intermediation costs and enhanced customer service would be achieved by the banking sector as a direct result of such liberalisation. The government and the CBJ argued that the enhancement of bank efficiency through deregulation would have a positive impact on the whole economy, given the important contribution of the banking system to economic growth. The Governor of the CBJ, Dr. Umayya Toukan (2002), stated:

> *"One of the fundamentals of Jordan's overall economic policy has been openness toward the international economy. In the light of this policy, Jordan undertook important liberalisation commitments in the process of its accession to the World Trade Organisation (WTO) with respect to financial services, including banking services. In addition to this, we aim to promote the soundness and the efficiency of banking system in Jordan" (Arab Banker, 2002).*

Despite this, the CBJ deregulated many aspects of bank operations but still imposed many restrictions. Table 4.4 summarises the main restrictions and regulatory requirements applied to Jordanian banks.

Table 4.4 Main Restrictions on Scope of Banks' Operation

Restrictions on Investment	Banks prohibited from holding more than 10% of company whose objectives do not include acceptance of deposits and owning shares, without prior written approval of CBJ, in any other bank or company that accepts deposits. Such ownership shall not in any case exceed 10 per cent of either its own subscribed capital or of subscribed capital of bank or company in which the bank owns shares; owning capital shares in companies, total of which exceeds percentage decided by CBJ. In all cases, this total shall not exceed 50 per cent of subscribed capital of bank. Where bank has exceeded this percentage, it shall be allowed five years from effective date of this law to rectify its state of affairs. Each bank acquiring at least 5% of the stocks and shares in capital of any company must notify CBJ within 15 days of date of the acquisition.
Restrictions on Loans	Real Estate Exposure: Banks prohibited from granting loans for construction or purchase of real estate in excess of 20% of total loans in JOD. Related-Party Exposure: Bank may not conclude deal with related party if deal can be undertaken in more favourable terms to bank with a third party who has no relationship with the bank; total related-party is limited to 50% of bank's subscribed capital and exposures to affiliates limited to 20% of their capital Loan Concentration Exposures: Overdraft facilities limited to 20% of bank's total loan portfolio; single name exposure limited to 25% of bank's subscribed capital excluding government-related entity exposures and cash-collateralised loans. Top ten exposures limited to 35 % of the bank's total loan portfolio for local banks and 70% for branches of foreign banks. In addition, concentration of economic sector is limited to 25% of total loan portfolio. Overdraft accounts may not exceed 20% of total direct loans.
Non-performing Loans Requirements	CBJ classified non-performing facilities as: - Sub-standard (overdue 90-179 days). - Doubtful (overdue180-359 days). - Loss (overdue more than 360 days). Banks required to take action on non-performing facilities, as follows: - 25% on sub-standard loans. - 50% on doubtful loans. - 100% on loss. Provisions on retail loans taken as: 15% for loans overdue for more than 30 days and less than 90 days, 25% overdue more than 90 days and less than 120 days, 50% overdue by more than 120 days and less than 180 days, 75% overdue for more than 180 days and less than 270 days, and 100% overdue by more than 270 days (these provisions are consistent with Basel II, standardised approach). Banks are required to take general provision equal to 1% of total loans.
Capital Requirements	Paid-up capital for Jordanian banks increased in 2003 from 20 to 40 MJOD and from 5 to 20 MJOD for foreign banks. Leverage ratio (total shareholders' equity to total assets) should be more than 6%. Minimum capital adequacy ratio set at 12 % (defined as Tier 1 and Tier 2[44] capital to risk weighted assets and market risks)[45].
Liquidity	Banks shall keep liquidity ratio of 100% for foreign currency denominated obligations and not less than 70% for JOD denominated obligations.
Opening New Branches	No banks can open branches inside or outside of Jordan without previous approval of CBJ.

Sources: CBJ (2004) and Standard & Poor's (2007).

[44] Tier 1 capital equals fully paid-up capital plus disclosed reserves plus retained earnings plus minority interest minus goodwill and any shortage in provisions (Basel, 1998). Tier 2 equals undisclosed reserve, revaluation reserves, general provisions, hybrid debt capital and subordinated loans (Basel, 1998).

[45] This ratio is according to Basel I guidance. From beginning of 2008 CBJ adopted Basel II guidance.

4.4 *Structure of Jordanian Banks*

Having discussed the background of the banking system in Jordan and the deregulation process undertaken by the CBJ, this section will focus on the structure of the Jordanian banks according to their ownership and specialisation. As shown in Chapter 3, these could play a crucial part in explaining the variation between banks' efficiency. Moreover, in this research they will be tested with regard to which kinds of ownership structure and specialisation are more efficient. In addition, this section will outline the structure of the Jordanian banks' balance sheet and income statement and how it changed over 1993-2006 as a result of deregulation.

4.4.1 Ownership structure of Jordanian banks

There are two types of banks in Jordan according to the ownership structure: foreign and domestic banks. Foreign banks are branches of international banks and are fully owned by foreigners and domestic banks are public ownership banks owned by Jordanians and foreigners. The entry of foreign bank branches into Jordan is subject to prior approval from the CBJ[46] and article 4 of the Banking Law of 2000 states: "No person shall engage in banking activities without first obtaining a final licence from the Central Bank, in accordance with the provisions of this law''. The minimum capital for the foreign banks wanting to operate in Jordan is 20MJ0D and this amount must be transferred into Jordan.

In regard to foreign ownership in Jordanian banks, the regulations before 1997 did not allow foreigners to own more than 49% of Jordanian banks but this was cancelled in 1997. Table 4.5 summarises the number of local and foreign banks and their total assets. The number of foreign banks was 5 in 1993-2003: in 2003 the CBJ granted a licence for an extra 3 banks to operate in Jordan. The market share of foreign banks (i.e. assets of foreign banks in relation to total assets of the banking system) remained constant over the period 1993-1997, at about 8%. After 1997, and as a result of the removal of constraints on the foreign exchange system, the market share of foreign banks rose to

[46] In addition to CBJ regulations regarding entry of foreign banks, CBJ applies Basel guidance regarding supervision of cross-border banking, which implies that all international banks should be supervised by a home country authority that capably performs consolidated supervision. Creation of a cross-border banking establishment should receive prior consent of both host country and home country authorities, and the latter should possess the right to gather information from their cross-border banking establishments (for more details, see Basel (1996)).

over 12 %. With regard to foreign ownership in local banks before 1997, ownership did not exceed 30% of the total assets of local banks. After 1997, as a direct result of the maximum limit of 49% regarding the size of FDI being eliminated, foreign ownership in the total assets of local banks reached 55% in 2006.

Table 4.5 Ownership Structure of Jordanian Banks

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Total Assets (MJOD[1])	5979	6679	7526	7824	8616	9425	10436	11474	12542	13225	13807	16090	19390	22523
Number of Banks	21	21	21	20	19	21	21	21	21	20	20	23	23	23
Domestic Banks	16	16	16	15	14	16	16	16	16	15	15	15	15	15
Foreign Banks	5	5	5	5	5	5	5	5	5	5	5	8	8	8
Domestic Banks' Assets (MJOD)	5465	6112	6888	7128	7848	8239	9099	10015	11080	11485	12270	14144	17049	19604
Percentage of domestic banks' assets from total assets	0.91	0.92	0.92	0.91	0.91	0.87	0.87	0.87	0.88	0.87	0.89	0.88	0.88	0.87
Foreign Banks' Assets (MJOD)	514	567	638	697	768	1185	1337	1459	1462	1740	1537	1947	2342	2918
Percentage of foreign banks' assets from total assets	0.09	0.08	0.08	0.09	0.09	0.13	0.13	0.13	0.12	0.13	0.11	0.12	0.12	0.13
Percentage of foreign ownership from domestic banks' total assets	0.33	0.32	0.29	0.31	0.45	0.47	0.47	0.48	0.51	0.51	0.51	0.51	0.54	0.55

[1]MJOD refers to millions of Jordanian Dinars and the JOD equals 1.41US Dollars. Values in nominal terms.
Source: Central Bank of Jordan Database 1993-2006.

4.4.2 Classification of Banks According to Specialisation

The Jordanian banking system is made up of commercial, Islamic and investment banks. The three different groups of banks operating in Jordan are subject to similar regulations (with the exception of foreign banks, which are also subject to their home country regulations) and the same market conditions. Commercial banks refer to banks dealing with traditional banking activities such as taking deposits and granting loans, while investment banks are more involved in capital market operations (e.g. issuing and selling securities), in addition to the brokerage service at the Amman Stock Exchange. Islamic banks must comply with Islamic Shariah law and avoid paying or receiving interest in any of its practices (Isik et al., 2004). Therefore, unlike commercial and investment banks, Islamic banks do not engage in giving fixed or predetermined rates of interest on financial transactions. According to the Islamic Shariah law, participants are allowed a share in the profit (loss) of Islamic banking operations but are not allowed to receive or give any kind of fixed rate (Isik et al., 2004). To cope with the Islamic Shariah law, the Islamic banks developed a variety of interest-free products, such as equity-participation and profit and loss sharing. In addition, Islamic banks are playing a role in rendering social services[47] to generally ignored poverty-stricken households (Hassan, 2005). Given the different behaviours of Islamic banks in relation to the commercial and investment banks and to their involvement in social activities, the Islamic banks incur more operational costs than the commercial or investment banks. Regardless of specialisation, all Jordanian banks (except foreign) are public shareholders and their shares are listed on the Amman Financial Market.

Table 4.6 shows the number of Jordanian banks and their total assets, according to specialisation. The table shows that commercial banks dominate the banking market in Jordan (the average total assets of commercial banks in 1993-2006 was about 83%, whilst for investment it was 9%, the same as for Islamic banks). These figures suggest that the Jordanian banking system is still traditional in its operations, i.e., in the taking of deposits and granting loans. Although investment banks have existed in Jordan since 1978, the scope of their operations is limited and concentrated in financing the working capital for some firms and the brokerage services in the Amman Financial Market. Investment banks around the world are generally involved in areas like capital markets

[47] An example of social services the Islamic banks render in Jordan is granting loans without any returns to poor students who want to finish their degree.

and hedging products, specialised services and giving advice on areas such as mergers and acquisitions (Gardener and Molyneux, 1993). The investments banks in Jordan do not operate in the above areas for various reasons: firstly, all investment banks in Jordan are owned and managed by families and the purpose of these banks, in most cases, is to benefit such families (e.g. finance companies related to family members). Secondly, the capital market in Jordan is still very basic; its operations include trading in the shares and bonds of public listed companies (PLCs), as well as government bonds, but over-the-counter trades, short sales, options, futures and other derivative trading are prohibited. Also, despite the CBJ's deregulating of many aspects of banking operations, its regulations still prohibit banks from owning capital shares in companies exceeding 50% of their subscribed capital. In addition, investment banks do not have specialised personnel capable of dealing with the advanced capital markets around the world.

Table 4.6 shows how the number of investment banks has declined in 1993-2006 from five to three banks. The reasons for this are that two of them (the Amman and Philadelphia banks) went bankrupt, due to mismanagement (Siam, 2007). These bankruptcies affected the reputation of investment banks and discouraged clients from dealing with them in Jordan.

Table 4.6 Classification of Banks According to Specialisation

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Total assets(MJOD)[1]	5979	6679	7526	7824	8616	9425	10436	11474	12542	13225	13807	16090	19390	22523
1.Commercial Banks														
Number	15	15	15	15	14	15	15	15	15	15	15	18	18	18
Total assets(MJOD)	4839	5442	6181	6584	7278	7817	8612	9631	10415	11077	11597	12903	16037	18478
Percentage of commercial banks' assets from total assets	0.81	0.81	0.82	0.84	0.84	0.83	0.83	0.84	0.83	0.84	0.84	0.80	0.83	0.82
2.Investment Banks														
Number	5	5	5	4	4	4	4	4	4	3	3	3	3	3
Total assets(MJOD)	612	667	723	622	687	743	850.8	961.3	1164	1024	1067	1657	1627	2007
Percentage of Investment banks' assets from total assets	0.10	0.10	0.10	0.08	0.08	0.08	0.08	0.08	0.09	0.08	0.08	0.10	0.08	0.09
3.Islamic Banks														
Number	1	1	1	1	1	2	2	2	2	2	2	2	2	2
Total assets(MJOD)	528	570	621	618	651	864	973.2	881.7	963.1	1124	1143	1531	1726	2038
Percentage of Islamic banks' assets from total assets	0.09	0.09	0.08	0.08	0.08	0.09	0.09	0.08	0.08	0.08	0.08	0.10	0.09	0.09

[1]MJOD refers to millions of Jordanian Dinars and JOD equals 1.41US Dollars. Values in nominal terms.
Source: Central Bank of Jordan Database 1993-2006.

4.4.3 Assets and Liabilities Structure

Tables 4.7 and 4.8 show the structure of assets and liabilities of Jordanian banks between 1993-2006. The total assets (liabilities) of the Jordanian banks amounted to 22,523 million JOD (Jordanian dinars) in 2006 and it has been noted that foreign assets represented an average of 26% of total assets in the years 1993-2006. Asset development was consistent with the rates achieved by the Jordanian economy in other economic fields and total assets rose from 5979 JOD million in 1993 to 22523 million JOD in 2006 (Miani and Daradkah, 2008). Table 4.7 and Figure 4.1 show the annual percentage growth of assets during 1993-2006: the average growth in assets was 11%. The total assets rose to 13% in 1994-1995 and after 1995 the growth rate slowed, ranging from 4 % to 11 % in 1996-2003. In this period, the banking industry in Jordan was subjected to a large number of changes:

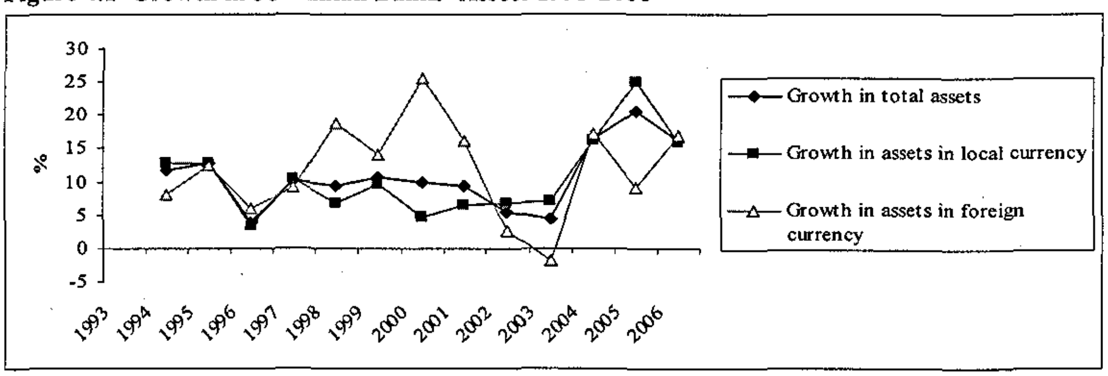
1. A decrease in customer deposits: Many Jordanians worked in the Gulf but returned to Jordan following the Iraq invasion of Kuwait in 1990 after the First Gulf War in 1991 (Isik et al., 2004) for political reasons. More than 300,000 people returned from Gulf countries in 1991-2000 and the remittance of these Jordanians was a main source of deposits in Jordanian banks (Tian and Zeitun, 2007).
2. Before the First Gulf War, Jordan was the main trading partner for Iraq. This was complicated by sanctions imposed on Iraq by the United Nations (UN) during the 1990s. Key Jordanian economic sectors such as transportation, agriculture and industry, mainly serving Iraq, were severely affected by the sanctions (El-Sakka, 2004) and tourism was disrupted as the number of tourists declined by almost 25%. In addition, some Gulf countries prohibited imports from Jordan because of their political position during the war. Jordanian agriculture and industry products were thus shut out from the most important Gulf countries' markets and this affected many economic sectors, especially banking (El-Sakka, 2004).
3. In the years 1999-2003, Jordanian banks faced many crises, such as the bankruptcy of the Philadelphia bank in 2002 due to fraud by bank management, and many banks (Jordan National Bank, Jordan Gulf Bank, Jordan Investment Bank and Export Bank) faced severe asset quality problems in 2001-2002 after they extended large amounts of loans (300 millions JOD) to a company whose

management had falsified contracts with Government departments (Standard and Poor's, 2007).

As a consequence of the above-mentioned crises, confidence in the Jordanian banking system significantly decreased, which in turn adversely affected the growth of bank deposits. However, from 2003 the growth rate in banks' total assets began to increase, as the Jordanian government pledged to guarantee the deposits of banks faced with asset quality problems: the CBJ required such banks to increase their capital, in order to absorb any losses. In 2004, the growth rate of total assets reached 17 % and this can be attributed to the three new foreign banks which came to work in Jordan. The year 2005 recorded a significant growth of 21% in total assets and by 2006 the figure was 16%.

Regarding analysis of the growth rate in assets according to currency, Figure 4.1 shows that assets in foreign currency significantly increased during 1997-2001, with the growth rate reaching 26% in 2000. The main reason for this may be largely attributed to the CBJ's having removed all restrictions from the foreign exchange system (see Table 4.3). After 2001, assets in foreign currency decreased considerably as a result of a decrease in foreign currency deposits. In this context, it should be noted that the CBJ had been working since 1995 to increase confidence in the national currency and promoted the Jordanian dinar as an attractive saving instrument. The main procedure used involved pegging the JOD with the US dollar and maintaining a spread of 2% between the interest rate of the indirect instrument of the CBJ (i.e. the CD) and that of the United States.

Figure 4.1 Growth in Jordanian Banks' Assets 1993-2006



Regarding the structure of assets in Jordanian banks, Table 4.7 suggests that in 1993-1997, the average percentage of loan to total assets was about 42%, whereas the average percentage of investments to total assets in the same period was about 6% and other earning assets (i.e. due from banks) around 36%. After 1997, the structure of the assets of Jordanian banks changed little; the percentage of loans from total assets decreased slightly to around 35% and the investment to total assets increased to around 13%. This change in the structure of the Jordanian banks' assets which can be attributed mainly to the CBJ's removal of restrictions in investment activities, especially those related to foreign investments (see Table 4.3), helped to change banks' attitudes towards asset and liability management and seeking new sources of income.

Table 4.7 Assets Structure and Growth for Jordanian Banks 1993-2006

Assets Side	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Total Assets (in foreign and local currency) (MJOD)[1]	**5979**	**6679**	**7526**	**7824**	**8616**	**9425**	**10436**	**11474**	**12542**	**13225**	**13807**	**16090**	**19390**	**22523**
Assets in foreign currency (MJOD)	1382	1492	1681	1782	1942	2304	2627	3298	3835	3930	3853	4516	4930	5764
Assets in Local currency(MJOD)	4596	5187	5845	6043	6674	7120	7809	8176	8707	9295	9954	11574	14460	16758
Growth in total assets (%)		12	13	4	10	9	11	10	9	5	4	17	21	16
Growth in assets in local currency (%)		13	13	3	10	7	10	5	6	7	7	16	25	16
Growth in assets in foreign currency (%)		8	13	6	9	19	14	26	16	2	-2	17	9	17
% of assets in local currency to total assets	77	78	78	77	77	76	75	71	69	70	72	72	75	74
% of assets in foreign currency to total assets	23	22	22	23	23	24	25	29	31	30	28	28	25	26
Assets Components														
1.Loans in local and foreign currency(MJOD)	**2367**	**2827**	**3292**	**3401**	**3482**	**3614**	**3656**	**3698**	**4108**	**4131**	**4346**	**5269**	**6861**	**8902**
Loans in local currency (MJOD)	2244	2703	3160	3275	3360	3466	3502	3550	3952	3962	4150	5095	6697	8671
Loans in foreign currency (MJOD)	123	124	132	126	122	148	154	148	156	169	196	174	165	231
Annual growth of loans (%)		19	16	3	2	4	1	1	11	1	5	21	30	30
Annual growth of loans in local currency (%)		20	17	4	3	3	1	1	11	0	5	23	31	29
Annual growth of loans in foreign currency (%)		1	6	-4	-3	22	4	-4	6	8	15	-11	-5	41
% of total loans to total assets	40	42	44	43	40	38	35	32	33	31	31	33	35	40
2.Total Investments (MJOD)	**484**	**457**	**366**	**375**	**526**	**751**	**916**	**1231**	**1727**	**1802**	**1735**	**2234**	**2813**	**3385**
Investment in local currency (MJOD)	370	360	265	281	320	507	622	804	1074	1067	935	1262	1870	2278
Investments in foreign currency (MJOD)	114	97	101	94	206	243	294	427	653	735	800	972	942	1107
Annual growth of total investments (%)		-6	-20	2	40	43	22	34	40	4	-4	29	26	20
Annual growth in investments in local currency (%)		-3	-26	6	14	59	23	29	34	-1	-12	35	48	22
Annual growth of investments in foreign currency (%)		-15	4	-7	119	18	21	45	53	13	9	21	-3	17
% of total investments to total assets	8	7	5	5	6	8	9	11	14	14	13	14	15	15
3.Total Due from banks (other earning assets) (MJOD)	**2158**	**2309**	**2672**	**2832**	**3169**	**3327**	**3883**	**4901**	**5570**	**5894**	**6201**	**6834**	**7570**	**7908**
Due from banks in local currency (MJOD)	622	591	844	816	1353	1214	1410	1897	2317	2646	3138	3198	2718	2791
Due from banks in foreign currency (MJOD)	1537	1718	1828	2017	1816	2113	2474	3004	3253	3248	3064	3636	4852	5116
Annual growth of total Due from banks (%)		7	16	6	12	5	17	26	14	6	5	10	11	4
Annual growth of Due from banks in local currency (%)		-5	43	-3	66	-10	16	35	22	14	19	2	-15	3
Annual growth of Due from banks in foreign currency (%)		12	6	10	-10	16	17	21	8	0	-6	19	33	5
% of Due from banks to total assets	36	35	36	36	37	35	37	43	44	45	45	42	39	35

[1]MJOD refers to millions of Jordanian Dinars and the JOD equals 1.41US Dollars. Values in nominal terms.
Source: Central Bank of Jordan Database 1993-2006.

1. Sources of Funds of Banks in Jordan

Sources of Jordanian banking funds can be generally divided into two main types: internal and external sources. Internal sources normally are long-term, and include banks' capital and reserves and subordinated debt by shareholders, whereas external sources are medium or short-term and include deposits from customers, inter-bank loans and loans from the CBJ.

Figure 4.2 and Table 4.8 show the structure of funding for Jordanian banks. Table 4.8 shows that the average percentage of equity to total sources of funds is about 8% and, according to the CBJ regulations, this ratio should be not less than 6%. In addition, the CBJ regulations require that the minimum paid-up capital for local banks should be 40 million JD (20 million prior to 2003) and 20 million JD (5 million prior to 2003) for foreign banks. One of the most important external sources of funds is customers' deposits and Table 4.8 suggests that the average customer deposit to total sources of funds is about 72%. Figure 4.2 shows that there is a steady decrease in the dependency of the banks on customers' deposits as a source of funds; however, there is a steady increase in dependency on equities and deposits of banks as sources. This could reflect that the CBJ encouraged banks to increase their equity by raising capital through capitalisation of profit. Also, the CBJ encouraged banks to deal in inter-banking operations, in order to form active money markets between banks. This helped those suffering from liquidity problems to have instant access to the active money market. From November 1996, the CBJ began to publish the weighted average of interest rates of inter-banks loans and this disclosure helped banks in increasing their effectiveness in managing their liabilities and assets and obtaining instant money from the market. *Customers' deposits still remain the cheapest and main source of funding for banks in* Jordan.

Table 4.8 Sources of Funds of Jordanian Banks (liabilities) 1993-2006

Liability Side	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1. Deposits from Customers (local and foreign currency) (MJOD)[1]	**4956**	**5404**	**5791**	**5944**	**6357**	**6806**	**7502**	**8226**	**6588**	**9229**	**10067**	**11685**	**13137**	**14566**
Deposits in local currency (MJOD)	3483	3734	3893	3970	4379	4802	5374	5804	4602	6346	7293	8536	9851	10901
Deposits in foreign currency (MJOD)	1474	1670	1898	1974	1978	2004	2128	2422	1986	2883	2774	3149	3286	3665
Annual growth of deposits (local and foreign currency) (%)		9	7	3	7	7	10	10	-20	40	9	16	12	11
Annual growth of deposits in local currency (%)		7	4	2	10	10	12	8	-21	38	15	17	15	11
Annual growth of deposits in foreign currency (%)		13	14	4	0	1	6	14	-18	45	-4	14	4	12
% of deposit from total liability and equity	83	81	77	76	74	72	72	72	53	70	73	73	68	65
Annual percentage change of customer deposits		9	7	3	7	7	10	10	-20	40	9	16	12	11
2. Deposits from Banks (MJOD)	**136**	**204**	**476**	**650**	**699**	**686**	**866**	**1063**	**3457**	**1513**	**1225**	**1302**	**2056**	**2625**
% of deposits from banks to total liability and equity	2	3	6	8	8	7	8	9	28	11	9	8	11	12
Annual percentage change of deposit from banks (%)		49	133	37	8	-2	26	23	225	-56	-19	6	58	28
3. Equity (MJOD)	**344**	**378**	**444**	**514**	**739**	**870**	**916**	**948**	**1046**	**1073**	**1165**	**1641**	**2008**	**2948**
% of equity from banks total liabilities and assets	6	6	6	7	9	9	9	8	8	8	8	10	10	13
Annual percentage change of equity (%)		10	17	16	44	18	5	3	10	3	9	41	22	47
Other Liability (MJOD)	**542**	**692**	**815**	**717**	**821**	**1063**	**1152**	**1238**	**1451**	**1410**	**1350**	**1463**	**2189**	**2384**
Total Liability and Equity (MJOD)	**5979**	**6679**	**7526**	**7824**	**8616**	**9425**	**10436**	**11474**	**12542**	**13225**	**13807**	**16090**	**19390**	**22523**

[1]MJOD refers to millions of Jordanian dinars. All values in nominal terms.

Source: Central Bank of Jordan Database 1993-2006.

Figure 4.2 Sources of Funds for Jordanian Banks 1993-2006

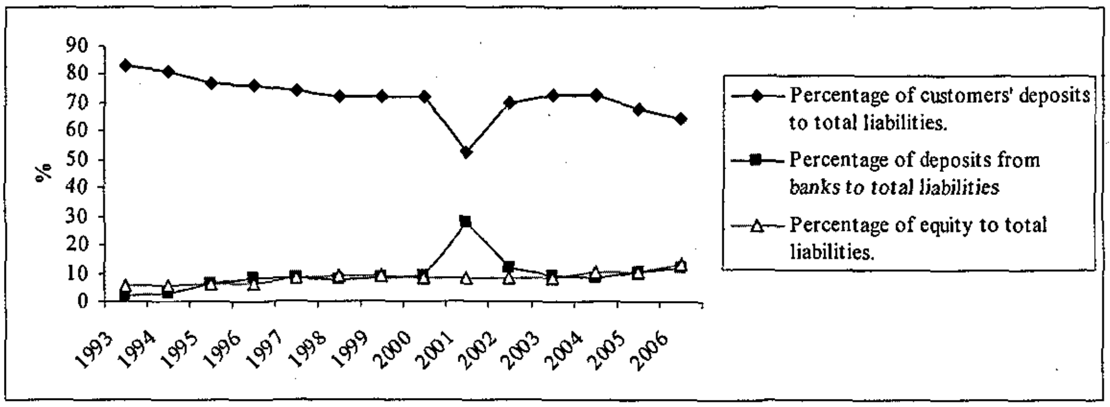
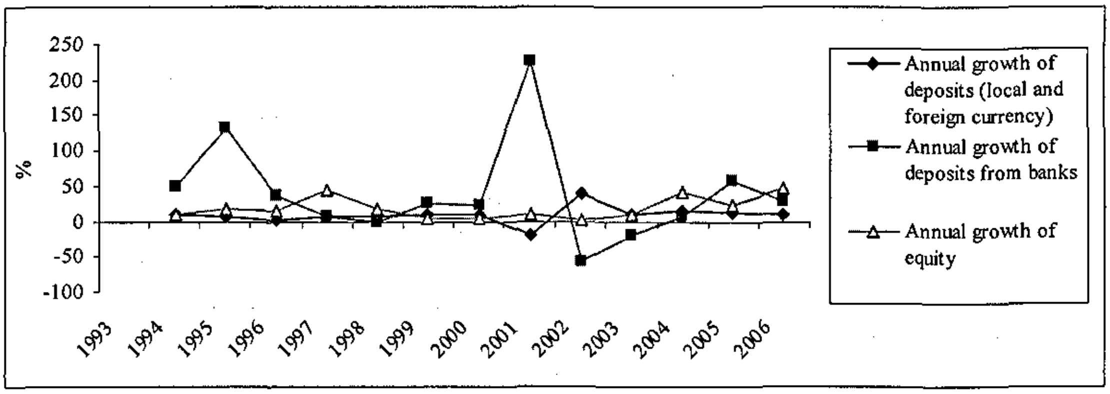


Figure 4.3 and Table 4.8 show the annual growth rate of the sources of funds for Jordanian banks between 1993-2006 and suggests that there is a steady increase of equities between 1993 and 1996: the average annual growth for this period is about 14%. In 1997, the growth rate in equities increased sharply and reached 44%, due to that the CBJ's requiring banks to increase their capital in order to meet Basel I guidelines regarding the capital adequacy ratio. In the years 1998-2003, the average growth rate in equities was about 8%, with growth increasing remarkably after 2003 as a result of the new CBJ regulations' requiring banks to increase paid-up capital.

Regarding customer deposits, Figure 4.3 shows how, during the years 1994-2000, the growth rate in customer deposits increased slightly and that the average increase was only 7%. In 2001, the growth rate decreased dramatically by 20%, due to the crises mentioned earlier. After 2001 and as a result of the crises, the government guaranteed banks' deposits and customer confidence returned: in 2002, the growth rate in customers' deposits reached 40%. The years 2003-2006 saw a steady growth rate in customer deposits and the average growth rate was about 12%. When the growth rate in deposits from banks is analysed, it is apparent that there was big growth during the years 1994-1996, with an average growth rate of 73%, related to the fact that the banks in Jordan became more aware of the importance of depending on each other to fill the gaps in liquidity and for the purposes of finding another source of funds, in view of the slowdown of a growth in deposits. In addition, the CBJ encouraged banks to deal with each other through inter-bank operations as a good motivation for banks with less liquidity to fill the gap by using inter bank loans with other banks with excess liquidity. During the years 1997-2000, the growth rate of deposits from banks slowed and the average growth was about 16%. However, in 2001, the growth rate increased remarkably, reaching 225%, and the main reason for this huge increase related to the crises facing Jordanian banks. This led to a decrease in the growth rate of customers' deposits and, in the following years, the growth rate in deposits from banks decreased sharply, in accordance with the fact that customers' confidence in the banks was restored and the growth rate of customers' deposits began to increase.

Figure 4.3 Annual Growth for Source of Funds of Jordanian Banks 1993-2006



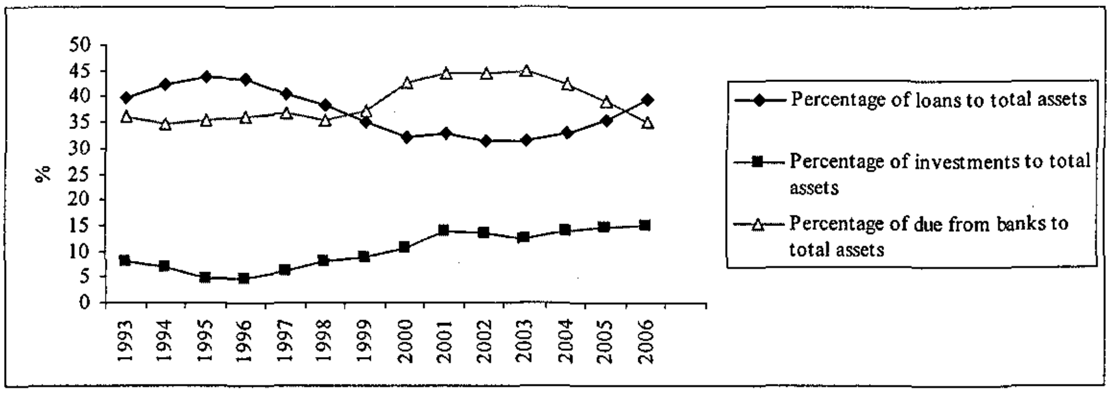
2. Uses of Funds in Jordanian Banks

The previous section concentrated on the sources of funds for the Jordanian banks and showed that the main source of funds in Jordanian banks is the customers' deposits. This section will establish how the funds in Jordan banks have been used. The banking sector in Jordan is one of the leading sectors in the national economy and has effectively contributed to enhancing economic development through its important role in mobilising domestic savings and channelling them into different fields of investment (CBJ, 2007). The funds in Jordanian banks were used to:

1. grant loans for the private and public sectors;
2. *invest in firms' stocks and governments bonds;*
3. deposit with local and international banks;
4. purchase the CBJ's certificate of deposits.

Figure 4.4 and Table 4.7 show the percentage of total loans, investments and due from banks to total assets: Figure 4.4 shows that, on average, loans in 1993-2006 totalled around 35% of total assets. A closer look at the development of the movement of loans in Jordanian banks indicates that the percentage of loans to total assets changed during the years 1993-2006. In the period 1993-1996, the average percentage was around 42% and this began to decrease between 1997-2003, when the average percentage of loans to total assets dropped to 34%. After 2004, the percentage of loans to total assets began to increase and reached the maximum of 40% in 2006. Figure 4.4 also shows that the percentage of investments to total assets in Jordanian banks has changed over the period 1993-2006: the average percentage of investments to total assets during the years 1993-1997 was about 6% and, in this period, there were many CBJ restrictions on banking investment, particularly in foreign currency. After 1997, many of these restrictions were removed and consequently the percentage of investments to total assets began to increase from 1998, reaching 15% in 2006. Finally, a closer look at the movement of due from banks over the period 1993-2006 indicates that the average of due from banks to total assets during 1993-1999 was 36%. After 1999, the average percentage of due from banks to total assets increased to 45%, an increase which can be attributed to the fact that, as mentioned earlier, some banks in Jordan faced a quality of loans problem. As a result of this, most banks reduced the granting of loans to customers and substituted this with purchasing CDs from the CBJ since the CBJ used to offer high interest rates on the CDs.

Figure 4.4 Percentage of Loans, Investments and due from Banks to Total Assets 1993-2006



To sum up, in 1993-2006, the structure of banks' assets and liabilities altered considerably. As a result of deregulation, banks had more sources from which to raise money and to produce a variety of products and services. For example, the use of a non-traditional source of funds - such as inter-banks loans - to fund loans' demand and other activities developed rapidly after 1997, as a result of the CBJ's beginning to publish the inter-banks loans' interest rate between banks. Liability management has received special attention from banks, due to the effects of volatile interest rates from interest rate deregulations. On the assets' side, banks had more choice in offering a variety of products and services, especially products related to foreign currency. From 1997, banks found it necessary to manage their interest rate-sensitive liabilities by increasing the proportion of variable rate lending and by shortening the maturities of loan contracts. Also, the banks in Jordan became more concerned about their liquidity, because new CBJ regulations helped banks to maintain a high level of liquidity and at the same time earn returns on it: for example, the issue of certificate deposits (CDs) from 1993 allowed banks to invest their funds in highly liquid assets and at the same time earn interest on these CDs. However, the change in the structure of banks' balance sheets could imply that banks might be becoming more risky. As mentioned earlier (see Table 4.3), the period 1996-2001 is characterised by removing restrictions on the scope of banks' operations. As a result, banks tend to use funds to invest in assets that may bring more revenues (e.g. purchasing stock). However, this kind of investment may be exposing banks to higher risks because of its high volatility.

4.4.4 Income Statements' Structure of Jordanian Banks 1993-2006

This section analyses the structure of the income statements of Jordanian banks and shows how deregulation has affected bank revenues and costs.

1. Revenues

Figure 4.5 and Table 4.9 show the sources of revenue in Jordanian banks. It is clear that the Jordanian banks depended on the income from interest on loans as the main source of income, with the average interest income from loans totalling 81% of all revenues during 1993-2006.

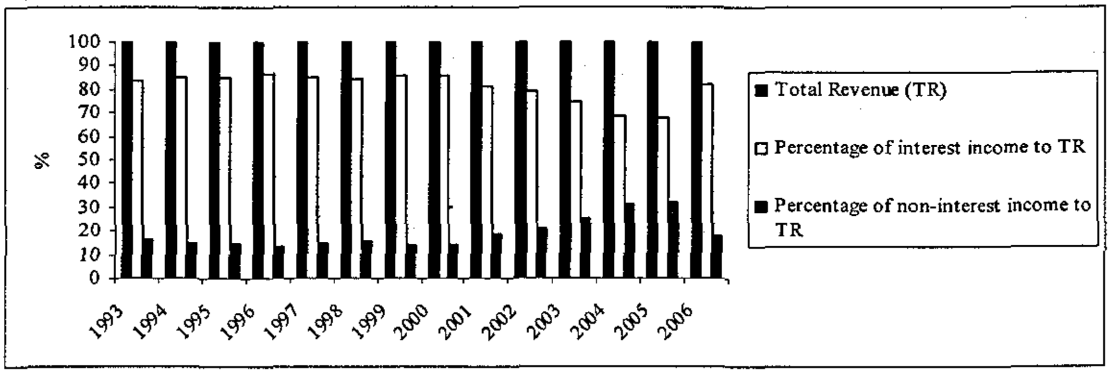
Regarding the movement of sources of income in Jordanian banks, Figure 4.5 shows how, during 1993-2001, interest from loans made up more than 80% of total revenue and after 2001 this percentage began to decrease, falling to 68% in 2005. It should be noted that in 2001-2005 there was a boom in the Amman Stock Market, as a result of many investors from Gulf Area invested heavily in the Jordanian companies, and many banks increased their investment in trading in stocks. This was reflected in the banking sector's performance to varying degrees: many banks were highly dependent on gains made from investment stock. The revenue from non-interest income after the year 2001 increased markedly. Overall, non-interest income has gradually become more important to Jordanian banks. The contribution of non-interest income to total revenues increased from 16% in 1993 to 32% in 2005. Moreover, during 2001-2005, the CBJ made a number of reductions in the interest rates of its instruments (e.g. CD) as a result of a reduction of interest rates within the international financial markets and also to reduce the cost of borrowing (Miani and Daradhah, 2008). As a result of this reduction, interest rates on loans decreased from 10% to 7% and the banks found it more profitable to invest their funds in stocks from the Amman Stock Market rather than to grant loans. In 2006, the CBJ raised the interest rate on its instruments and thus interest rates on loans increased. In this year, the income from interest rates on loans totalled 82% of all revenue.

Table 4.9 Income Statements Structure for Jordanian Banks 1993-2006

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Revenues (TR)(MJOD)[1]	**418**	**472**	**618**	**664**	**721**	**779**	**807**	**857**	**855**	**715**	**669**	**766**	**1192**	**1444**
Annual percentage growth in TR (%)		13	31	7	9	8	4	6	0	-16	-6	15	56	21
Component of revenues														
1. Interest Income[2] (MJOD).	**350**	**401**	**526**	**576**	**615**	**657**	**692**	**738**	**696**	**563**	**501**	**527**	**808**	**1187**
% of interest income of TR	84	85	85	87	85	84	86	86	82	79	75	69	68	82
2. Non-interest income[3] (MJOD).	**67**	**72**	**92**	**88**	**106**	**122**	**116**	**119**	**158**	**152**	**168**	**239**	**384**	**258**
% of non-interest income of TR	16	15	15	13	15	16	14	14	18	21	25	31	32	18
Costs (TC) (MJOD).	**368**	**415**	**534**	**574**	**634**	**671**	**742**	**792**	**729**	**593**	**521**	**527**	**693**	**926**
Annual percentage change in TC (%)		13	29	7	10	6	11	7	-8	-19	-12	1	32	34
Component of costs														
1. Interests expenses[4] (MJOD).	**226**	**258**	**338**	**378**	**426**	**425**	**454**	**492**	**423**	**293**	**216**	**204**	**319**	**546**
% of interest expenses of TC	61	62	63	66	67	63	61	62	58	49	41	39	46	59
2. Non-interest expenses (operating expenses)[5] (MJOD).	**142**	**157**	**196**	**196**	**208**	**245**	**288**	**301**	**305**	**300**	**305**	**323**	**374**	**380**
% of non-interest expenses of TC	39	38	37	34	33	37	39	38	42	51	59	61	54	41
Net Profit (NP) (TR-TC) (MJOD).	**50**	**57**	**84**	**90**	**87**	**108**	**66**	**65**	**126**	**122**	**147**	**239**	**500**	**518**
Annual percentage growth in NP (%).		15	47	7	-3	24	- 39	-1	94	-3	21	62	109	4
Average interest rates for loans.	0.10	0.10	0.10	0.11	0.12	0.12	0.12	0.12	0.10	0.09	0.08	0.07	0.07	0.08
Average interest rates for deposits.	0.04	0.04	0.05	0.05	0.06	0.05	0.05	0.05	0.04	0.02	0.02	0.01	0.02	0.03
Average margin[6].	0.054	0.053	0.049	0.058	0.060	0.067	0.070	0.067	0.062	0.064	0.061	0.054	0.052	0.049

[1]Millions of Jordanian dinars. All values in nominal terms.
[2]Interest income includes interest received from loans and deposits in banks.
[3]Non-interest income includes commissions and incomes from investments.
[4]Interest expenses include interest paid on deposits from customers and banks.
[5]Non-interest expenses include staff expenses, maintenance costs, depreciation and other administrative cost.
[6]Average margin equals average interest rates on loans minus average interest rates on deposits.
Source: Central Bank of Jordan Database 1993-2006.

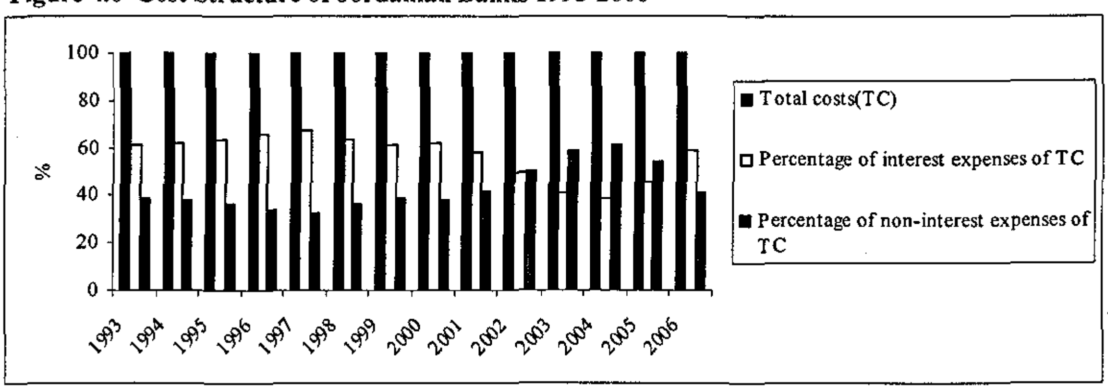
Figure 4.5 Revenues Structure of Jordanian Banks 1993-2006



2. Costs

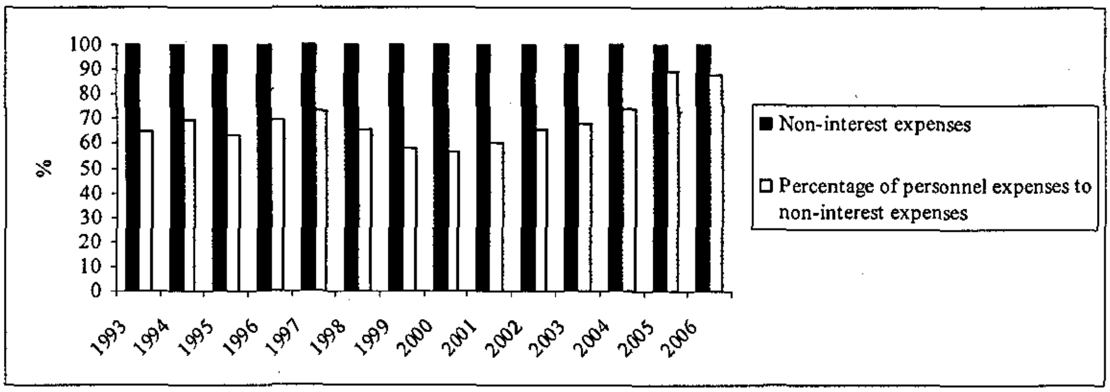
Figure 4.6 and Table 4.9 show the sources of costs in Jordanian banks. As Figure 4.6 suggests, average interest and non-interest expenses, as a proportion of total costs, were 57% and 43%, respectively, between 1993-2006. Figure 4.6 also indicates that during 1993-2001 the percentage of average interest expenses as a proportion of total costs was more than 60%. In the period 2002-2005, the average of non-interest income as a percentage of total costs exceeded 50%, more than interest expenses. As mentioned earlier, during this period, the CBJ reduced interest rates on its instruments; banks responded by reducing interest rates paid on deposits and charged on loans. In 2006, the CBJ increased the interest rates on its instruments and interest rates paid on deposits were raised accordingly.

Figure 4.6 Cost Structure of Jordanian Banks 1993-2006



With regard to non-interest expenses, Figure 4.7 shows how the average of administrative expenses to non-interest expenses totalled more than 65% of non-interest expenses over the years 1993-2006: this high percentage suggests that operating expenses are considered high within the Jordanian banks. The increase in the staff and management expenses could be an indicator for the slack management (see Chapter 2) in Jordanian banks.

Figure 4.7 Personnel Expenses to Non-Interest Expenses 1993-2006



3. Net Profits

The net profit for banks is considered a main factor in gauging banks' performance (Berger and Mester, 1997). Figure 4.8 shows the Jordanian banks' revenues, costs, and net profits,[48] and Figure 4.9 shows the annual growth rate of revenues, costs and net profits for Jordanian banks.

Figure 4.8 Development of Jordanian Banks' Profitability 1993-2006

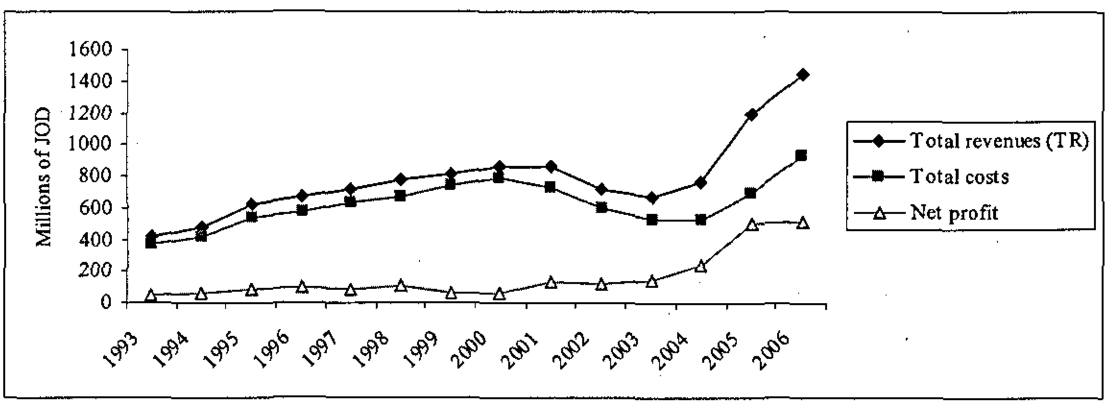
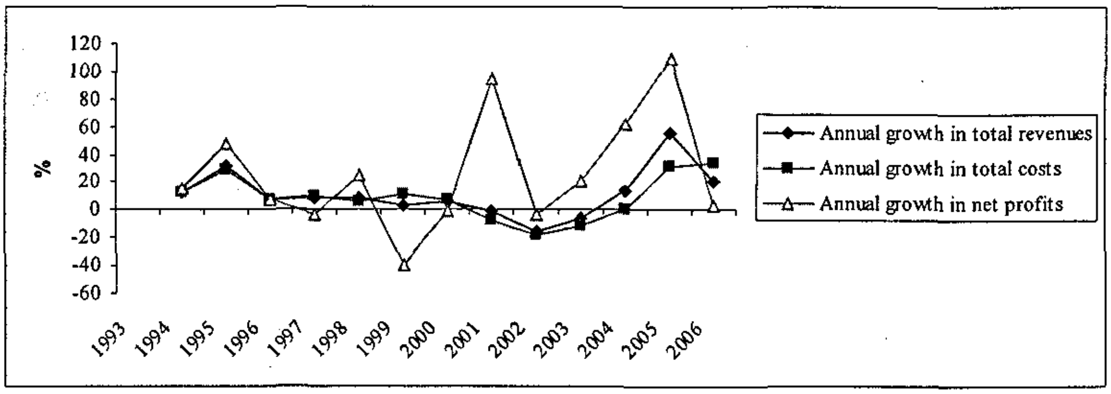


Figure 4.8 indicates that there was a steady increase in banks' revenues and costs during the years 1993-2000 and a close look at the gap between revenues and costs reveals that between 1993-2000 the gap was fairly constant but after 2001, the gap began to widen. This indicates that, during 1993-2001, banks were concentrating on traditional banking

[48] Net profits equal revenue minus costs.

activities which depended on taking deposits from customers and granting loans with a specific margin of profits (i.e. the difference between the interest rates paid and received). After 2000, as a result of the CBJ allowing the banks to engage in different activities and services (see Table 4.3), the gap between the banks' revenues and costs became wider, which shows that banks began to vary there sources of income (i.e. non-interest income). A close look at the movement of banks' net profits (Figure 4.8) shows that, during 1993-1997, profits were almost steady, with little improvement: this is understandable, since banks in this period were dependent on traditional activities (i.e. receiving deposits and granting loans). During 1998-2000, Jordanian banks faced a decline in their profits because most were under provision because of to the weak structure of the supervision in the CBJ. Before 1997, there were two departments responsible for banks' supervision: on-site and off-site supervision departments. The off-site supervision staff at the CBJ are provided with financial statements and periodical reports on banks' performances, in order to evaluate estimates and analyse risks associated with their conduct and performance. Whereas, on-site supervision is concerned with on-site visits to banks by inspectors, aimed at inspecting the accuracy of the financial data and periodical reports submitted to the CBJ. The periodicity of on-site visits by CBJ supervisors differs from one financial institution to another, depending on their risk rating. The level of coordination between the two departments was very limited and the off-site department had the power in deciding all issues relating to bank supervision and regulation, in particular the appropriateness of banks' bad loans provision. The decision-making of off-site departments depended on the periodic reports sent by banks; on-site reports were not really taken into account. In 1997, the management of the CBJ discovered that most Jordanians banks were suffering from non-performing loans (i.e. the non-performing loans increased from 20% in 1996 to 45% in 1997) and under-provision (i.e. the bad loan provision was not enough) and decided to merge the two departments. The main aim of the CBJ in this decision was to ensure that all parties (i.e. off-site and on-site) were responsible for all decisions regarding the banks' supervision. After merging the on-site and off-site in one department, the CBJ asked banks to increase their provision, which in turn decreased their profits. Moreover, in the light of the weak supervision structure within the CBJ and as a result of removing restrictions on the scope of banks' operations, the Jordanian banks engaged in very risky products (e.g. derivatives) and this led to many Jordanian banks' incurring big losses between 1997-2001.

Figure 4.9 Growth Rates of Revenues, Costs and Net Profits 1993-2006



During 2001-2006, net profits yielded an increase, especially in 2004 and 2005: growth in net profits (see Figure 4.9) reached 62% in 2004 and an amazing 109% in 2005. This remarkable increase can be attributed to the boom in the Amman Stock Market as most of the banks' profits in these two years came from stock trading.

4.5 Financial Ratio Analysis for Jordanian Banks 1993-2006

Financial ratios performance measures are heavily used by regulators and are based on accounting information rather than on microeconomic theory (i.e. consider input prices and output mix) (Fiorentino et al., 2006). In this section, key financial ratios are presented as a measure for banks' performance. These are return on average assets (ROA), return on average equity (ROE), total cost to total revenues, cost-income-ratio (CIR), non-performing loans to total loans and staff-expenses to total assets. The first two ratios measure the ability of banks to generate earnings and profits and the next four measure the ability of banks to save costs. It should to be noted that this analysis is built in ratio analysis and this does not mean that cost and profit efficiency is improved, based on the frontier methods. Thus improvement in financial ratios does not necessary lead to the same conclusion in frontier analysis.

4.5.1 Profit Performance Measures

The most commonly-used ratios for measuring banks' (profit) performance are ROA and ROE (Tian and Zeitun, 2007). ROA is calculated as net profit before tax divided by average assets, and it measures the ability of assets used by bank to generate profits. The ROE equals profits before taxes divided by average equity, and it measures the rate of return shareholders receive on their investment.

Figure 4.10 and Table 4.10 show the ROA and ROE for Jordanian banks between 1993-2006. As Figure 4.10 suggests, between 1993-2001 there was little or no improvement in the profitability indicators for Jordanian banks. The ROA is almost constant, while the ROE increased during 1993-1996, then dropped off from 1997 onwards. A close look at Figure 4.10 indicates that Jordanian banks witnessed a remarkable improvement in their performance between 2001-2005. For example, ROA and ROE reached 2.58% and 24.88%, respectively, in 2005, compared with 1.5% and 14.5% in 2004. The stock market boom, especially in 2005, was the main driver of this improvement (Standard and Poor's, 2007). As result of the deregulation brought about by the CBJ, the contribution of non-interest income to total income increased sharply in 2001-2005, mainly from the brokerage services and market-related gains. The downturn in the stock market in 2006 affected the performance of Jordanian banks; both the ROA and the ROE decreased to 2.3% and 17.59%, respectively.

Figure 4.10 ROE and ROA of Jordanian Banks 1993-2006

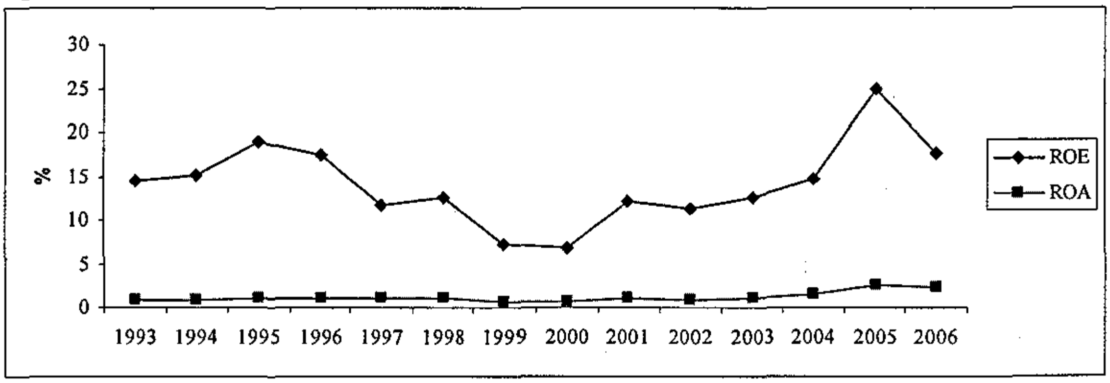


Table 4.10 Profit Performance Measures 1993-2006

Year	ROE (%)	ROA(%)
1993	14.44	0.83
1994	15.11	0.86
1995	18.92	1.12
1996	17.48	1.15
1997	11.81	1.01
1998	12.46	1.15
1999	7.16	0.63
2000	6.84	0.56
2001	12.02	1.00
2002	11.36	0.92
2003	12.63	1.07
2004	14.58	1.49
2005	24.88	2.58
2006	17.59	2.30

4.5.2 Cost Performance Measures

The most commonly used ratio to measure the ability of banks to control costs is the cost-income-ratio (CIR) (Forster and Shaffer, 2005). This ratio is defined by the US Federal Financial Institutions Examination Council as: CIR= non-interest expenses[49]/ (non-interest income + net interest income[50]). A smaller CIR ratio indicates greater cost savings. In addition to this, the following ratios are calculated (1) the ratio of staff expenses over total assets (S/TA)[51] measures manpower expenses, (2) the ratio of non-performing loans to total loans (NPL)[52] measures extra expenses (e.g. provisions costs, monitoring costs) that banks pay, due to non-performing loans, and (3) total costs to total revenues (TC/TR)[53] measures how much of revenues the bank uses to cover costs.

[49] Non-interest expenses include salaries, technology, buildings, supplies and administrative expenses.
[50] Net interest income equals interest income less interest expenses.
[51] Smaller S/TA ratio indicates greater costs saving.
[52] Smaller NPL ratio indicates greater costs saving.
[53] Smaller TC/TR ratio indicates greater costs saving.

Figure 4.11 and Table 4.11 show the CIR, NPL, S/TA and TC/TR for Jordanian banks between 1993-2006. As Figure 4.11 indicates, CIR for Jordanian banks between 1993-1998 was high (in excess of 70%) and almost constant. In 1999-2000, this ratio increased, but in 2001 it began to decrease, reaching 41% in 2006, which indicates that the cost performance for Jordanian banks improved after 2001. NPL decreased between 1993-1996, but this ratio increased remarkably between 1997-1999 as a result of the crises that faced Jordanian banks. From 2000 onwards, the ratio began to decrease and reached 7% in 2006. TC/ TR for Jordanian banks between 1993-1998 was high (in excess of 80%) and almost constant. During 1999-2000, this ratio increased and reached 90%, but in 2001 it began to decrease, reaching 64% in 2006. Finally, staff expenses to total assets were almost constant between 1993-2000 and began to decrease after 2001.

Figure 4.11 Cost Performance Indicators for Jordanian Banks 1993-2006

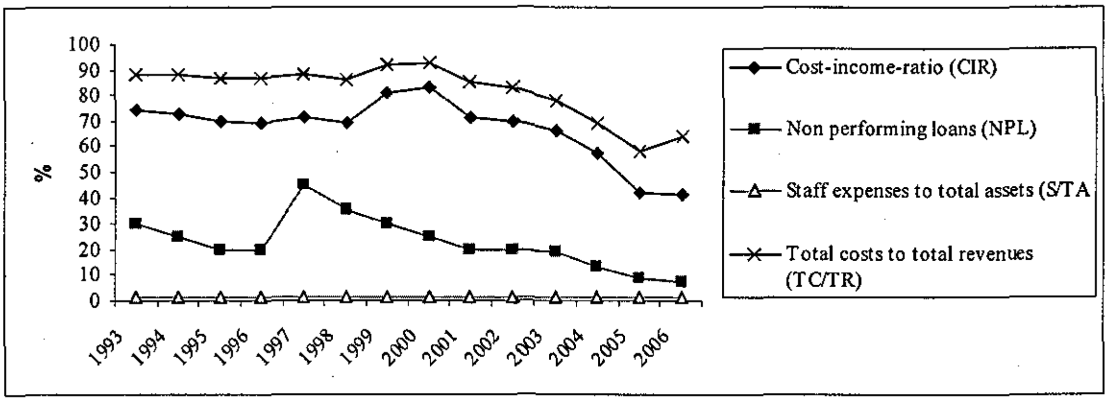


Table 4.11 Cost Performance Indicators for Jordanian Banks 1993-2006

Year	Cost-income ratio (CIR) (%)	Non-Performing loans (NPL) (%)	Staff expenses to total assets (S/TA) (%)	Total costs to total revenues (TC/TR) (%)
1993	74	30	1.55	88.12
1994	73	25	1.63	87.90
1995	70	20	1.66	86.40
1996	69	20	1.73	86.46
1997	71	45	1.77	87.90
1998	69	35	1.71	86.09
1999	81	30	1.59	91.87
2000	83	25	1.48	92.44
2001	71	20	1.47	85.28
2002	70	20	1.49	82.95
2003	66	19	1.51	77.98
2004	57	13	1.49	68.77
2005	42	9	1.72	58.09
2006	41	7	1.48	64.11

Thus, the profit and costs indicator for Jordanian banks showed no significant improvements over 1993-2000 but witnessed remarkable improvements after 2001.

4.6 Competition in the Jordanian Banking Industry

As discussed earlier, one of the key objectives of the deregulation of banks was to promote competition by (i) allowing foreign banks to enter the domestic market and (ii) allowing foreign investors to hold common stocks in domestic banks. The Herfindahl index (HI) and the spread of interest rates between loan interest and deposit interest rates are the most commonly used tools to measure the level of competition within the banking industry (Berger and Humphrey, 1997). The HI is the sum of squared market share (e.g. deposits) of all banks in the market and the formula is used:

$$HI = \sum_{i=1}^{n} (x_i/x)^2$$

where x_i represents the deposits of the i-th bank and x represents the total deposits for the banking sector as whole. HI can take a value between zero and one.

When HI is approaching one, this implies the market is highly concentrated and the level of completion is very weak; when HI is approaching zero, this implies the market is more competitive. Molyneux et al. (1996) suggest that the HI is responsive to the number and dispersion of firms in the market and is therefore generally viewed as a superior measure of concentration in the market than other measures such as three-firm concentration ratio (CR3). Thus a declining HI shows a declining trend in concentration or an increase in competition.

The spread of interest rates measures price competition among Jordanian banks and is calculated as the difference between the interest rates on loans and deposit interest rates. A high spread of interest rates could imply that banks have market power to impose high interest rates on lending and low interest rates on deposits (Molyneux et al., 1996). Thus, a declining rate of spread in interest rates is a signal of an increase in competition. Figure 4.12 and Table 4.13 show the trends of the HI and the spread of interest rates within the Jordanian banking industry between 1993-2006. Figure 4.12 shows a declining trend in concentration between 1993-2000, which implies that there was an increase in competition levels within Jordanian banking. In 2001, the trend of concentration increased, which might suggests that the level of competition will have decreased. In this year and as mentioned earlier, some banks suffered from severe asset quality problems after extended loans to fake companies and thus confidence within the banking sector waned significantly. During this year, most depositors withdrew their deposits from banks facing problems and re-deposited their monies in banks without them. This led to increase in the market shares of such banks, which in turn was reflected by the increase in concentration in the market. After 2001, the concentration trend of the Jordanian banking industry declined due to the intervention of the Jordanian government and the CBJ, which resulted in renewed customer confidence in banks facing problems and return of their deposits to these banks. The CBJ also allowed three foreign banks to operate in Jordan, which further promoted competition levels in Jordanian banking (i.e. the HI decreased from 0.16 in 1993 to 0.13 in 2006).

With regard to price competition measured by interest rate spread, the figure shows that between 1993-1995 and as a result of the liberalisation of interest rates, the spread of the interest rates declined, suggesting that the price competition amongst Jordanian banks increased slightly as the banks became more able to decrease interest rates on loans and increase rates on deposits. During 1996-1999, the interest rate spread increased as a result of the CBJ issuing CDs at high interest rates, which in turn encouraged banks to invest in these CDs and raise the interest rate on loans. From 2000 onward, the price competition heated up amongst Jordanian banks, with the interest rate spread falling to a low of 0.04 in 2006.

Figure 4.12 Competition Trends in Jordanian Banking 1993-2006

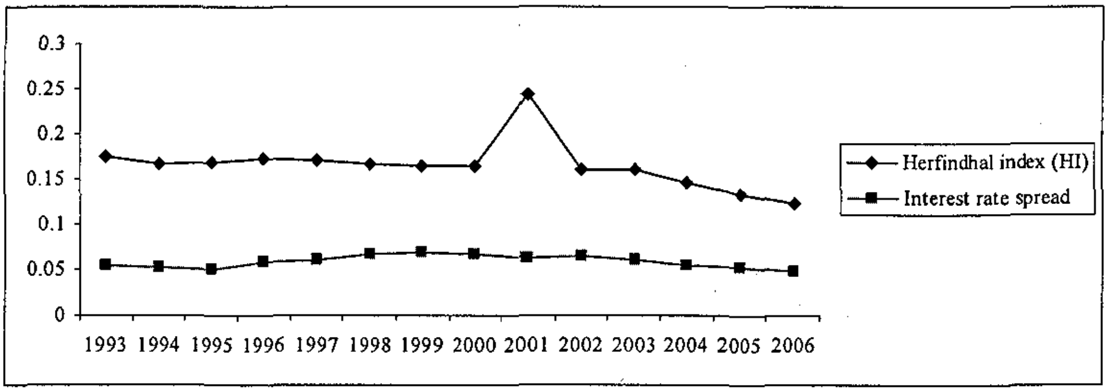


Table 4.12 Competition Trends in Jordanian Banking 1993-2006

Year	Herfindhal index (HI)	Interest rate spread	Year	Herfindhal index (HI)	Interest rate spread
1993	0.17	0.054	2000	0.16	0.067
1994	0.17	0.053	2001	0.24	0.062
1995	0.17	0.049	2002	0.16	0.064
1996	0.17	0.058	2003	0.16	0.061
1997	0.17	0.06	2004	0.15	0.054
1998	0.17	0.067	2005	0.13	0.052
1999	0.17	0.07	2006	0.12	0.049

4.7 Deriving Research Hypotheses

As explained earlier, this research seeks to investigate the efficiency of Jordanian banks in the context of financial sector liberalisation implemented in Jordan in the early 1990s. Chapter 3 outlined that the operation of banks may be highly correlated to the regulations that govern banking operations (see Mahoon and Murray, 1981). It was argued that the banking system in many developing countries experiences poor performance and low levels of efficiency, which are attributed to heavy governmental intervention in the banking system and the restrictions imposed on the scope and operation of banking activities (Kumbhakar and Sarkar, 2003). Mahoon and Murray (1981) argued that government regulation and deregulation were important factors that could affect the strategic choice of managers, which in turn could affect financial performance and risk. Within a strict regulatory environment, the banks' choices are limited and this will have a direct and indirect effect on bank performance through a restriction of the banks' strategic options. Deregulation of the financial system can also reap benefits, such as producing a variety of the products and services that may enhance profitability and efficiency through the optimal use of resources when producing bank outputs (Merrick and Saunders, 1985). It could also create a competitive banking system with the potential to produce the optimum quantity of money and optimising resources used in producing bank services and products (Friedman, 1969).

However, deregulation may be accompanied with costs that can threaten the safety and soundness of the financial system, such as banks being more likely to invest in risky products (Merrick and Saunders 1985). Gruben and McComb (1997) reported that the newly deregulated banks' portfolios in Mexico became more risky because they could not evaluate the riskiness of loans and higher real interest rates under deregulation.

Studies investigating the effects of deregulation in developing countries (see Chapter 3) in general, reported a positive impact of deregulation on banking efficiency (Gilbert and Wilson, 1998; Leightner and Lovell, 1998 Kumbhakar and Sarkar, 2003; Isik and Hassan, 2003; Ataullah et al. 2004; Williams and Nguyen, 2005); many studies, however, conclude that deregulation has no significant impact on banking efficiency (Katib and Mathews, 2000; Hao et al., 2001; Okuda et al., 2002; Williams and Intarachote; 2002; Kraft et al. 2006).

Indeed, empirical evidence (for more details see Chapter 3) on the impact of deregulation on banks' efficiency has been mixed: Berger and Humphrey (1997) point out that the results of deregulation may essentially depend on how the conditions of the industry have been regulated and also on the type of deregulation measures implemented. The institutional environment of the banking system plays a vital role in determining deregulation effects on bank efficiency. For example, Demirguc-Kunt and Detragiache (1998) have mentioned that countries with weak institutional environments, characterised by weak legal enforcement, inefficient bureaucracies and corruption, are more prone to instability in their financial systems after deregulation; and thus deregulation could lead to a decrease of efficiency in the banks in the period immediately after liberalisation. In the light of measures taken by the CBJ to deregulate the banking system in Jordan and as this research is looking at the efficiency levels of Jordanian banks before and after the liberalisation process, accordingly we hypothesise:

Hypothesis 1: Bank efficiency has improved since the implementing of deregulation in Jordanian banking system.

This hypothesis will be tested by comparing efficiency scores over the study period. This will give an indication of the extent to which the steps taken by the CBJ have affected positively or negatively the banks' efficiency level. Moreover, dummy variables will be used to account for specific years when many important deregulation processes were undertaken by the CBJ.

In addition to hypothesis 1, and as mentioned in Chapter 2 and 3 there are many factors may have an impact on the level of banks' efficiency, such as internal bank-specific factors (size, ownership structure, specialisation, age, corporate control) and external environmental factors (concentration) and their impact on banks' efficiency. This research seeks to test many conceptual issues that are related to bank-specific factors and market condition. As shown in Chapter 2, there are many theories which have emerged (e.g. managerial discretion theory, behavioural theory) which considered the firm (bank) as nexus of contracts among different 'opportunistic' parties. The ability of the firm (bank) therefore to transfer inputs into outputs is a function of internal specific variables and external factors.

In the light of the literature reviewed in Chapter 3 and the main characteristics of the Jordanian banks reviewed earlier in this chapter, the following hypotheses will also be tested:

Hypothesis 2: Foreign banks are more cost (profit) efficient than domestic banks.

Hypothesis 3: Specialised banks are less cost (profit) efficient.

Hypothesis 4: Bank size is positively related to cost (profit) efficiency.

Hypothesis 5: Well-established banks are more cost (profit) efficient than newly established banks.

Hypothesis 6: CEO-Chairman affiliation is negatively related to banks' cos(profit) efficiency (i.e. chairman of bank board and CEO are the same person).

Hypothesis 7a: High concentration is negatively related to cost (profit) efficiency.

Hypothesis 7b: High market share is positively related to cost (profit) efficiency.

The variables that will be used to test hypotheses 2-7 and the justification for hypotheses 2-7 will be discussed in more detail in Chapter 5 when selecting variables that will be used to account for differences between Jordanian banks.

4.8 Conclusion

The main features of the Jordanian banking system during 1993-2006 were reviewed in this chapter. The system is made up of commercial banks, Islamic banks and investment banks. The commercial banks dominate the banking market in Jordan with market share exceeding 80 per cent. There are two types of banks according to ownership: foreign banks and domestic banks.

The banking and financial system accounted for an average 17 per cent of Jordan's GDP and the value of Jordanian banks' assets exceeded GDP in all years 1993-2006. This may give an indicator about the crucial role the banking system is playing in economic development and growth in Jordan.

A programme of economic and structural reforms was initiated in Jordan in early 1989, triggered by an economic crisis that included low foreign currency reserves, high fiscal deficits, high inflation rates and high unemployment rates. A key element of the 1989 reforms, the financial deregulation programme, included: efforts to increase competition; allowing banks to operate with more freedom; and strengthening supervision and prudential measures. The CBJ took several steps to liberalise the banking system in Jordan. The liberalising procedures included removing restrictions on interest rates, reducing government-directed lending, expanding of product deregulation and removing of restrictions on foreign exchange transactions. Also, the maximum limit of 49 per cent, regarding the size of foreign investment in the Jordanian banks, was eliminated and banks were given greater autonomy to manage their assets and liabilities. In line with its objective to enhance the effectiveness and efficiency of the monetary policy (in addition to developing the money market and activating the inter-bank market), the CBJ took many steps, such as publishing weekly interest rates regarding inter-bank loans and introducing an overnight deposit facility to help banks to manage their liquidity better.

To promote the soundness and safety of Jordanian banks, the CBJ adopted the best practices of the international central banks, such as enhancing the culture of risk management and adopting Basel's guidance on capital adequacy and corporate governance. Despite the CBJ taking many steps to deregulate the banking system in Jordan, banks are still subject to many restrictions such as those on investments and lending.

The deregulation put in place by the CBJ directly affected the structure of banks' balance sheets and income statements. The use of non-traditional fund sources (i.e. inter-bank loans) to fund loans and other activities developed rapidly after 1993 and liabilities-assets management received considerably more attention, due to the removal of interest rate ceilings; interest rates became more volatile, which in turn forced banks' management to balance their interest- sensitive liabilities by increasing the proportion of variable rate lending. After 1993, Jordanian banks concentrated on short-term lending, with only a few corporate loans stretching beyond three years. On the income statements' side, banks became more aware of non-interest income and this source of income increased after 1993: the percentage of non-interest income of total revenue increased from 16% in 1993 to 32% in 2005. However, such deregulation measures subjected Jordanian banks to high risks and instabilities within their financial system, particularly the measures taken in 1997-2001.

Competition in Jordanian banking improved after 1993, as a result of non-Jordanians' being permitted to own more than 50% of Jordanian bank stocks and the allowing of more foreign banks to operate in Jordan. The concentration ratio in Jordanian banking decreased from 17% in 1993 to 12% in 2006 and an analysis of the financial indicators of Jordanian banks in 1993-2006 shows that there was little improvement in these indicators over the period 1993-2000. At this time, the Jordanian banks were adversely affected by political situations within the region and the crises that Jordanian banks faced in 1999-2001 also did not help. From 2001, all the financial indicators of Jordanian banks improved, suggesting that the efficiency of the financial and banking system is likely to have improved after this time. The remaining chapters will investigate empirically the efficiency of the banks in Jordan by employing parametric and nonparametric approaches to see how the deregulation measures put in place affected the level of banks' efficiency. Moreover, the next chapters will explore many conceptual issues regarding efficiency of Jordanian banks. These issues will concentrate on bank-specific factors, ownership structure and market conditions. The exploration of these issues may help in understanding why banks differ with respect to theirs levels of efficiency.

Chapter 5 Methodology and Data

5.1 Introduction

The financial intermediaries, especially banks, play a crucial role in the process of economic growth by intermediating scarce resources in the economy (Levine, 1997). Given that the commercial banks in developing countries handle most of the intermediating activities (Fry, 1995) by collecting deposits from customers and re-channelling these into various economic activities. For example, restrictions imposed by the regulatory authorities limit the options available to banks in transforming their funds into earning assets.

The preceding chapter reviewed the bank deregulation measures introduced in Jordan during 1993-2006. The main aims were to promote a diversified, efficient and competitive financial system, through measures such as improving resources' allocation and financial viability and operational flexibility (Toukan, 2002). This chapter describes and employs parametric stochastic frontier approach (SFA) and nonparametric data envelopment analysis (DEA) to measure cost and profit efficiency within Jordanian banks during 1993-2006. The aim is to examine whether the cost and profit efficiency of banks improved after the introduction of the deregulation.

This chapter is organised as follows. Section 5.2 outlines the SFA and DEA methodologies used in this study to estimate the cost and profit efficiency measures for Jordanian banks. Section 5.3 describes the sample which comprises data for all banks operating in Jordan in 1993-2006 and also presents and explains the different variables used in this study. Section 5.4 outlines the model specification: that is, the functional form used to derive cost and profit functions, estimation of different models, structure tests to obtain the preferred model and deriving the best model that will be used to measure the efficiency scores.

5.2 Methodology

As mentioned in Chapter 3, there are two approaches used in the literature for frontier estimation of various industries: nonparametric and parametric. Both of these approaches attempt to benchmark the relative performance of production units by estimating the best-practice frontier although they differ in the assumptions imposed on the data. In this study, a parametric approach (i.e. SFA) will be mainly employed in order to estimate cost and profit efficiency for Jordanian banks. To test the consistency of the efficiency estimates derived from SFA, this study will also use a nonparametric approach (i.e. DEA) to measure cost and profit efficiency. This section provides some technical details of the SFA and DEA approaches.

5.2.1 Stochastic Frontier Approach (SFA)

The most commonly used technique to measure efficiency is the SFA. As mentioned in Chapter 2, the SFA was proposed independently by Aigner, Lovell and Schmidt (1977) and Meeusen and Van den Broeck (1977). The general model for SFA can be written as:

$$\ln y_i = \beta_m \ln x_{mi} + \ln \varepsilon_i \tag{5.1}$$

where $\ln y_i$ is the natural logarithm of the output of the i-th bank, x_{mi} is a vector of M inputs of the i-th bank, β_m is a vector of unknown parameters and ε_i is a two-component error term of the form:

$$\varepsilon_i = v_i - u_i \tag{5.2}$$

v_i is a random error component that permits the random variation of the frontier across banks and captures the effects of measurement errors, other statistical noise and random shocks outside the bank's control. This error term is assumed to be independently and identically distributed normal random variables, with zero mean and variance σ^2. u_i is a non-negative and one-sided error component that follows an asymmetric half-normal distribution that captures the effects of inefficiency relative to the stochastic frontier. The value of u_i indicates the level of inefficiency: if u_i is equal to zero, there is no inefficiency, and if u_i is more than zero, the inefficiency is present and is called technical efficiency (TE). The most common output-orientated measure of TE is the ratio of observed output to the corresponding frontier output (Coelli et al., 2005):

$$\mathrm{TE}_i = \frac{y_i}{\exp(\beta x_{mi} + v_i)} = \frac{\exp(\beta x_{mi} + v_i - u_i)}{\exp(\beta x_{mi} + v_i)} = \exp(-u_i) \tag{5.3}$$

where TE_i is a measure of technical efficiency of the i-th bank and takes a value between zero and one, y_i is the observed output of the i-th bank and $\exp(\beta x_{mi} + v_i)$ is the frontier output. Thus TE_i measures the output of the i-th firm relative to the output that could be produced by a fully-efficient firm using the same inputs vector (Coelli et al., 2005).

Cost and Profit Efficiency

Equations 5.1 and 5.3 focuse on the technical-physical aspect of production. When price data are available for inputs and outputs and it is assumed that banks aim to minimise costs or maximise profit, we can estimate cost and profit efficiency for banks. The behavioural assumptions of cost minimisation and profit maximisation are appropriate for banks (Coelli et al., 2005). Berger and Mester (1997) determined three concepts that offer a definitional framework for the meauring of cost and profit efficiency in the banking industry: cost efficiency, standard profit efficiency and alternative profit efficiency.

1. Cost Efficiency

Cost efficiency gives a measure of how close a bank's cost is to the cost of best practice bank producing the same output bundle under the same conditions (Berger and Mester, 1997). It is derived from a cost function in which variable costs depend on the prices of variable inputs, the quantities of variable outputs, any exogenous variables, random error and inefficiency.

To measure the cost efficiency (CE_i) of the i-th bank (i = 1……I), a banking firm's observed total cost is modelled to deviate from the cost-efficient frontier, due to random error and inefficiency. The stochastic cost frontier model can be written as:

$$\ln\mathrm{TC}_i = f(w_{ni}, y_{ki}, c_{ri}, \beta, z_i) + \ln v_i + \ln u_i \tag{5.4}$$

where $\ln\mathrm{TC}_i$ is the natural logarithm of the observed total cost of the i-th bank, $f\,()$ is the functional form of the cost frontier, w_{ni} is a vector of input prices (n=1.....N) for the i-th bank, y_{ki} is the vector of output levels (k=1.....K) for the i-th bank, c_{ri} represents the vector of control variables (c=1....C) that may have an effect on the i-th bank cost frontier, β represents a set of parameters to be estimated and z_i represents a set of environmental variables (using control and environmental variables will be discussed in detail in the data section) that may have an effect on the level of a bank's inefficiency (i.e., on u_i)[54]. The measure of CE_i for the i-th bank is given by the ratio of minimal cost (estimated cost) to actual cost (observed cost) and can be written as:

$$CE_i = \frac{\exp(f(w_{ni}, y_{ki}, c_{ri;}\beta, z_i) + v_i)}{\exp(f(w_{ni}, y_{ki}, c_{ri}; \beta \; , z_i) + v_i + u_i)} = \frac{1}{\exp(u_i)} \tag{5.5}$$

Equation 5.5 measures the minimal cost that can be incurred by an efficient bank (numerator in equation 5.5) against the actual costs incurred by the i-the bank (denominator in equation 5.5). The cost efficiency ratio may be thought of as the proportion of costs that are used efficiently. For example, a bank with CE_i of 0.70 is 70% efficient or equivalently wastes 30% of its costs relative to the best-practice firm facing the same conditions. Cost efficiency ranges over (0, 1) and equals one for the best-practice firm within the observed data.

2. Standard Profit Efficiency

Standard profit efficiency (SPE) measures how close a bank is to achieving the maximum possible profit given a particular level of input prices and output prices (and other variables) (Berger and Mester, 1997). In contrast to the cost function, the standard profit function specifies variable profits in place of variable costs.

To measure the standard profit efficiency (SPE_i) for an individual bank$_i$ (i = 1......N), a banking firm's observed profit is modelled to deviate from the profit-efficient frontier, due to random error and inefficiency. The stochastic profit frontier model can be written as:

$$\ln NP_i = f(w_{ni}, p_{ri}, c_{ri}, \beta, z_i) + \ln v_i - \ln u_i \tag{5.6}$$

[54]The composite error term for the cost frontier is equal to $v_i + u_i$ becuase u_i, representing inefficiency increases the cost. The composite error term for the profit frontier equals v_i - u_i since, u_i representing inefficiency decreases profit.

where $\ln NP_i$ is the natural logarithm on net profit (revenues minus total costs) and p_{ri} is the vector prices of variable outputs for the i-th bank.

The measure for profit efficiency (SPE_i) for the i-th bank is given by the ratio of actual profit to maximum profit and can be written as:

$$SPE_i = \frac{\exp(f(w_{ni}, p_{ri}, c_{ri}; \beta\ , z_i) + v_i - u_i)}{\exp(f(w_{ni}, p_{ri}, c_{ri}; \beta\ , z_i) + v_i)} = \exp(-u_i) \qquad (5.7)$$

SPE_i is the proportion of maximum profits earned, so that a SPE ratio of 0.70 would indicate that the bank is losing about 30% of the profits it could be earning. Similar to cost efficiency, profit efficiency equals one for the best-practice firm that maximises profits.

3. Alternative Profit Efficiency

Berger and Mester (1997) argued that the profit frontier in equation 5.6 may not be an appropriate measure of bank efficiency if the following conditions are not met:

1. There are no differences in banks' output quality;
2. Banks have no power over the prices they charge, as a result of the market's being perfectly competitive; and
3. Output prices are accurately measured.

However, in reality, some banks do earn more revenue because of differences in the quality of outputs. Also, the banking market cannot be described as being a perfectly competitive industry, as some banks do exercise market power to earn abnormal profits (Berger and Hannan, 1998). The concept of alternative profit efficiency was developed by Berger and Mester (1997) as a solution to the problems that may arise when the assumptions underlying profit efficiency are not met. The alternative profit efficiency (APE) uses the same dependent variable as the profit function and the same independent variables as the cost function. APE may be written as:

$$\ln NP_i = f(w_{ni}, y_{ki}, c_{ri}, \beta, z_i) + \ln v_i - \ln u_i \qquad (5.8)$$

The measure for APE for the i-th bank is given by the ratio of actual profit to maximum profit and can be written as:

$$APE_i = \frac{\exp(f(w_{ni}, y_{ki}, c_{ri}; \beta\ , z_i) + v_i - u_i)}{\exp(f(w_{ni}, y_{ki}, c_{ri}; \beta, z_i) + v_i)} = \exp(-u_i) \quad (5.9)$$

Similar to standard profit efficiency, alternative profit efficiency equals one for the best-practice firm that maximises profits.

The first step in predicting the cost, standard profit and alternative profit efficiency (CE, SPE and APE) is to estimate the parameters (β) of the stochastic cost/profit frontiers in equations 5.4, 5.6 and 5.8. As the right-hand side of these equations includes two error terms (u_i and v_i), the estimation is slightly complex. As is typical of most efficiency studies, it is assumed that the v_i are normally distributed with mean 0 and variance σ_v^2 and the u_i are non-negative and half-normally distributed with zero mean and variance σ_u^2. Also, v_i and u_i are assumed to be distributed independently of each other and independently of the input and output variables. With these distribution assumptions, the method of maximum likelihood (ML) is used in the estimation of the parameters (β). This method is an estimation technique that estimates the unknown parameters in such a manner that the probability of observing the given data (i.e. total cost) is as high (or maximum) as possible (Gujarati, 2003). The use of this method of estimation requires assumptions about (1) the distribution of the error terms u_i and v_i (e.g. normal distribution), (2) density functions for u_i and v_i, and (3) the joint density function for u_i and v_i (for details, see Kumbhakar and Lovell 2000). Maximising the log-likelihood function usually involves taking the first-derivatives with respect to the unknown parameters and setting them to zero (Coelli et al., 2005). In many cases, when the first derivative conditions are highly nonlinear and cannot be solved, iterative optimisation procedures are needed to find the value that maximises the log-likelihood function (Coelli et al., 2005). The likelihood function which represents the joint density function of u_i and v_i can be defined as enabling one to employ maximum likelihood techniques in order to estimate the parameters in the equations (5.4), (5.6) and (5.8)[55]. Taking the log of the likelihood function, we get the log-likelihood function[56] for equation (5.4)[57] :

[55] For more detail, see Kumbhakar and Lovell (2000).

[56] Use of log-likelihood function rather than likelihood function is for computational reasons, and the two functions give the same value.

[57] In estimating profit efficiency, the procedures followed are same as for estimating cost efficiency.

$$\ln l(TC_i/\beta,\sigma,\lambda) = \frac{N}{2}\ln\frac{2}{\pi} - N\ln\sigma - \frac{1}{2\sigma^2}\sum_{i=1}^{N}\varepsilon_i^2 + \sum_{i=1}^{N}\ln\left[\Phi(\frac{\varepsilon_i\lambda}{\sigma})\right] \quad (5.10)$$

where TC_i is a vector of log-total costs, β a set of parameters to be estimated, N is the number of banks, $\sigma^2 = \sigma_v^2 + \sigma_u^2$, $\lambda = \frac{\sigma_u}{\sigma_v + \sigma_u}$, $\varepsilon_i = v_i + u_i = \ln TC_i - f(w_{ni}, y_{ki}, c_{ri}, \beta_i)$ and Φ (.) is the standard normal cumulative distribution function (Allen and Rai, 1996).

After estimating the parameters (β,σ,λ) in equation (5.10), using maximum likelihood techniques, the composite error term $\varepsilon_i = v_i + u_i$ is calculated. Then, the existence of inefficiency (u_i) in composite error terms (ε_i) is tested[58] by observing the skewness of the joint distribution of $\varepsilon_i + v_i + u_i$. If the distribution of the composite error terms is positively skewed in the case of the cost frontier (or negatively for the profit frontier), the one-sided error component u_i dominates the random error v_i in the determination of ε_i. Aignar et al. (1977) showed that for the half-normal case, an estimate of the mean inefficiency is given as:

$$E(u) = \sigma_u\sqrt{\frac{2}{\pi}} \quad (5.11)$$

where E(u) is the expected mean for u_i. Aignar et al. (1977) suggested that $[1 - E(u)]$ should be used as an estimator of the mean of cost efficiency for all banks.

The above estimation is the estimated mean of cost efficiency for all banks. To obtain estimates of the cost efficiency for each bank, stochastic frontier analysis is directed towards the separation of the random error (v_i) from inefficiency (u_i) and the prediction of the inefficiency effects for each bank. Jondrow, Lovell, Materov and Schmidt (1982) presented a solution to separate the random error from inefficiency by obtaining the conditional distribution of u_i given ε_i. The expected value of u_i conditional on the composed error term ($\varepsilon_i = v_i + u_i$), for the half-normal model is shown as:

$$E[u_i/\varepsilon_i] = \frac{\sigma\lambda}{(1+\lambda^2)}\left[\frac{\varphi(\varepsilon_i\lambda/\sigma)}{\Phi(\varepsilon_i\lambda/\sigma)} + \frac{\varepsilon_i\lambda}{\sigma}\right] \quad (5.12)$$

[58] Details of testing for the existence of inefficiency in the composite error term will be discussed later in the model specification section.

where E[.] is the expectation operator, φ [.] is the density of standard normal distribution, Φ [.] is the cumulative density function, $\sigma = \sqrt{(\sigma_u^2 + \sigma_v^2)}$ and $\lambda = \frac{\sigma_u}{\sigma_v + \sigma_u}$.

The value of λ provides an indication of the relative contribution of u_i and v_i to ε_i. As λ approaches 0, with either σ_v^2 approaching $+\infty$ or σ_u^2 approaching 0, the random error component dominates the one-sided error component in the determination of ε_i (when $\lambda = 0$ all deviation from the efficient frontier is due to the random error and hence no cost inefficiency). As λ approaches $+\infty$, with either σ_u^2 approaching $+ \infty$ or σ_v^2 approaching 0, the one-sided error component dominates the random error component in the determination of ε (when $\lambda = 1$ all deviations from the frontier are due to cost inefficiency) (Kumbhakar and Lovell, 2000)[59].

4. Scale Efficiency

As indicated in Chapter 2, scale economies refer to the proportional increase in cost resulting from a proportional increase in the level of output (i.e. the elasticity of total cost with respect to output). Following Mester (1996) and Altunbas et al. (2001), scale economies will be calculated at the mean values of outputs, input prices and control variables for the respective size quartiles[60] of banks and within all banks. As the calculation is based on the means of outputs, input prices and control variables, the estimated first order coefficients of outputs can be interpreted as cost elasticities regarding outputs. A measure of economies of scale (SE) is given by differentiating the cost function (i.e. cost elasticity) in equation (5.4) with respect to outputs (i.e. y). This is presented as:

$$SE = \sum_{k=1}^{K} \frac{\partial \ln TC}{\partial \ln y_k} \tag{5.13}$$

The degree of scale economies is given by the sum of individual cost elasticities: if the calculated SE < 1, then we have increasing returns to scale (implying economies of

[59] It should be note that all discussions in section 5.2.1 are based on assumptions that u and v are distributed half-normal. For other models of distribution (e.g. exponential distribution), procedures remain the same but the log-likelihood function should be based on the density function of exponential distribution. For more details of other distributions, see Kumbhakar and Lovell (2000).

[60] Banks under study will be divided into many groups according to asset size.

scale); if SE = 1, then we have constant returns to scale, and if SE > 1, then we have decreasing returns to scale (implying diseconomies of scale).

5.2.2 Data Envelopment Analysis (DEA)

In this study, DEA will be used to check the robustness of SFA results. As mentioned in Chapter 2, DEA is a nonparametric approach, using a linear programming method to construct a piece-wise combination yielding a convex production possibility set that enveloped all firms (banks) in the sample. The efficiency of each bank within the sample is then calculated relative to the surface (i.e. frontier) (Coelli et al., 2005). Below is a mathematical explanation of different DEA models.

1. Constant Returns to Scale

Charnes, Cooper and Rhodes (1978) introduced a basic DEA model (CCR model) able to deal with many inputs and outputs by assuming constant returns to scale and the efficiency measures derived are based on maximising the ratio of all outputs over all inputs. Coelli et al. (2005) explained the approach of DEA by assuming there are data on M inputs $m = (1....M)$ and K outputs $k = (1....K)$ for each I firm. For the i-th firm, the set of inputs and outputs can be represented by the column of input vector x_i and the column of output vector y_i. The input matrix, $X = (N \times I)$ and the output matrix $Y = (K \times I)$ represent the data for all I firms.

Efficiency measures derived using DEA are based on the maximisation of the ratio of outputs over inputs for each firm; for example, $u'y_i/v'x_i$, where u is an $(K \times I)$ vector of output weights and v is an $(N \times I)$ vector of input weights. The optimal weights are obtained by solving the following mathematical problem:

$$
\begin{aligned}
&\mathrm{Max}_{u,v} \quad (u'y_i/v'x_i) \\
&\text{subject to} \quad u'y_j/v'x_j \leq 1 \quad j = 1,2,....,I \\
&\qquad\qquad u, v \geq 0
\end{aligned}
\tag{5.14}
$$

Equation 5.14 implies that finding the values of u and v will maximise the efficiency measure for the i-th firm, subject to the constraints that the ratio of 'virtual output' vs.

'virtual input' should not exceed 1 for every firm. However, at this stage, a problem regard the infinite number of solutions to linear programming appears but to overcome this problem, the constraint $v'x_i = 1$ is imposed in order to replace the fractional programme to linear programme that is:

$$\begin{aligned} &\text{Max}_{v,u} \quad (\mu' y_i) \\ &\text{subject to } vx_i' = 1 \\ &\qquad \mu' y_j - v' x_j \leq 0 \quad j = 1,2,\ldots,I \end{aligned} \tag{5.15}$$

where the change of notation from u and v to μ and v is used to reflect that this is a different linear programming problem. By using the duality in linear programming[61], the dual of the above maximisation problem can be written in the following envelopment form:

$$\begin{aligned} &\text{Min}_{\theta\lambda} \quad \theta \\ &\text{subject to} \quad Y\lambda \geq y_i \\ &\qquad \theta x_i \geq X\lambda \\ &\qquad \lambda \geq 0 \end{aligned} \tag{5.16}$$

where θ is an efficiency score and λ represents the weights given to the reference firms used to evaluate the performance of the i-th firm under evaluation to become efficient (the reference firms represent firms that are efficient and located on the efficient frontier). The weight represents the percentage of inputs of reference firms that inefficient firms should use to become efficient. The value of θ obtained is the efficiency score of the i-th firm, where $0 \leq \theta \leq 1$. If θ has a value equal to one, the firm lies on the frontier and hence is a technically efficient firm, according to Farrell's (1957) definition. It should be noted that the linear programming problem must be solved *n* times, once for each firm within the sample (Coelli et al., 2005). A value of θ is then obtained for each firm. The objective function of DEA is to minimise the efficiency

[61] Duality means changing objective from maximising output/input ratio to minimising input usage. For more detail, see Cooper et al. (2007). The dual for equation (5.15) is minimising $v'x_i = 1$, denoted by θ, *and the dual for* $u'y_i . v'x_j \leq 0$ *is* λ. *It should be noted that each of primal and dual gives the same solution.* Using dual aims to reduce the number of constraints, since the number of constraints under primal equals the number of firms under evaluation, whereas the numbers of constraints under dual equal the number of inputs and outputs.

score θ (which represents the amount of radial reduction in the use of input vector x_i) as much as possible, whilst still remaining within the feasible input set. The radial contraction of the vector x_i produces a projection point ($Y\lambda$, $X\lambda$) on the efficient frontier and the constraints ensure that this projection belongs to the feasible production set (Coelli et al., 2005). DEA generates the efficiency frontier as a linear combination of the efficient observed data, rather than assuming an explicit functional form a *priori*; the difference between the vector x_i and the projection point ($Y\lambda$, $X\lambda$) measures inefficiency.

2. Variable Returns to Scale

Equation 5.16 assumes that constant returns to scale (CRS) are imposed on every observation in the sample. However, factors, such as imperfect competition and government regulation, may cause a firm not to operate at an optimal scale (Coelli et al., 2005). It is therefore sometimes reasonable to adopt a variable returns to scale (VRS) model, as suggested by Banker, Charnes and Cooper (1984): the VRS ensures that a firm is only compared with firms of a similar size. Therefore the CRS linear programming may be modified to account for VRS by adding the convexity constraint $\sum\lambda = 1$ to the equation (5.16), as below:

$$\begin{aligned} &\mathrm{Min}_{\theta,\lambda} && \theta \\ &\text{subject to} && Y\lambda \geq y_i \\ & && \theta x_i \geq X\lambda \\ & && \sum\lambda = 1 \\ & && \lambda \geq 0 \end{aligned} \tag{5.17}$$

The introduction of the constraint $\sum\lambda = 1$ ensures that firms operating at different scales are recognised as efficient; therefore envelopment is formed by the multiple convex linear combinations of best practice (incorporating VRS) (Ramanathan, 2003). It should be noted that with this approach a firm is only benchmarked against firms of a similar size, whilst under CRS a firm may be benchmarked against firms that are substantially larger (or smaller) (Coelli et al., 2005).

3. Cost Efficiency and Profit Efficiency

The above focused on the technical efficiency of banks. However, as mentioned in Chapter 2, the concept of technical efficiency does not consider input and output prices and therefore does not consider whether firms in the industry are allocating their inputs and outputs according to their prices in the optimal proportion. Similar to the SFA approach, if the behavioural assumptions of a firm's objectives, such as cost minimisation, profit maximisation and reliable prices information, are available for inputs and outputs, DEA can be used to identify cost and profit efficiency (allocative efficiency) (Cooper et al., 2007).

(i) Cost efficiency

For cost minimisation, this research measures input-orientated efficiency with VRS. The cost model is written as:

$$\begin{aligned} &\text{Min}_{\lambda x_i} && w'x_i^* \\ &\text{subject to} && Y\lambda \geq y_i^* \\ & && x_i^* \geq X\lambda \\ & && \lambda = 1 \\ & && \lambda \geq 0 \end{aligned} \qquad (5.18)$$

where w_i is a vector of input prices for the i-th bank and x_i^* is the cost minimisation vector of input quantities for the i-th bank, given the input prices w_i and the output level y_i (input orientation technical efficiency, see Chapter 2). Cost efficiency (CE) can be presented as a product of technical and allocative efficiency measures and the CE of the i-th bank is calculated as:

$$CE = w_i'x_i^*/w_i'x_i \qquad (5.19)$$

where CE is cost efficiency, $w_i'x_i^*$ is minimum cost and $w_i'x_i$ is the observed cost. Thus, CE is the ratio of minimum cost to observed cost, for the i-th bank, and takes a value ranging from 0 to 1, where a value of 1 refers to full efficiency.

(ii) Profit efficiency

For profit maximisation, this research measures output-orientated efficiency and the profit model is written as:

$$
\begin{aligned}
&\text{Max}_{\lambda, y_i^*, x_i^*} \quad (p_i' y_i^* - w_i' x_i^*) \\
&\text{subject to} \quad Y\lambda \geq y_i^* \\
&\qquad\qquad\quad x_i^* \geq X\lambda \\
&\qquad\qquad\quad \lambda = 1 \\
&\qquad\qquad\quad \lambda \geq 0
\end{aligned} \tag{5.20}
$$

where p_i is a vector of output prices for the i-th bank and y_i^* is the revenue-maximising vector of output quantities for the i-th bank, given the output prices p_i and the input level x_i (for output orientation technical efficiency, see section 2.3.1). The profit efficiency (PE) can be presented as the product of technical and allocative efficiency measures and the (PE) of the i-th bank is calculated as:

$$PE = (p_i' y_i - w_i' x_i)/(p_i' y_i^* - w_i' x_i^*) \tag{5.21}$$

where PE is the profit efficiency, $p_i' y_i - w_i' x_i$ is the observed profit and $p_i' y_i^* - w_i' x_i^*$ is the maximum profit. Thus PE is the ratio of observed profit to maximum profit, for the i-th bank and takes values ranging from 0 to 1, where a value of 1 refers to full efficiency.

4. New Cost and Profit Efficiency

The cost and profit efficiency in equations 5.19 and 5.21 are based on the technical aspects of the banks and assumes that all banks are operating in a competitive market and facing the same input and output prices. However, Tone (2002) pointed out that there was a *shortcoming with the cost and profit efficiency measures* as used in the DEA literature. He observed that if two decision making units (DMU) held the same amounts of inputs and outputs, and one's unit cost for inputs was twice as much as the other's, using the traditional cost efficiency model will show that the two units have the same cost efficiency (for more details, see Cooper et al., 2007). To solve this problem, Tone (2002) proposed new cost efficiency (NCE) by taking the total cost of each unit, which is equal to the price of inputs multiplied by the quantity of inputs. The NCE model of the i-th bank is written as:

$$\begin{aligned}
&\mathrm{Min}_{\bar{x}\lambda} \quad e\bar{x} \\
&\text{subject to} \quad \bar{x} \geq \bar{X}\lambda \\
&\qquad y_i \leq Y\lambda \\
&\qquad \lambda = 1 \\
&\qquad \lambda \geq 0
\end{aligned} \tag{5.22}$$

where e is a row vector with all elements being equal to 1, $\bar{x} = w_i' \times x_i^*$ (w_i' the price of inputs and x_i the quantity of inputs). NCE for the i-th bank is equal to:

$$\mathrm{NCE} = e\bar{x}_i^* / e\bar{x}_i \tag{5.23}$$

where $e\bar{x}_i^*$ is the minimum cost and $e\bar{x}_i$ is the observed cost.

Similiarly the new profit efficiency (NPE) of the i-th bank is written as:

$$\begin{aligned}
&\mathrm{Max}_{\bar{x},\bar{y},\lambda} \quad e\bar{y} - e\bar{x} \\
&\text{subject to} \quad \bar{x} \geq \bar{X}\lambda \\
&\qquad \bar{x} \geq \bar{X}\lambda \\
&\qquad y_i \leq Y\lambda \\
&\qquad \lambda = 1 \\
&\qquad \lambda \geq 0
\end{aligned} \tag{5.24}$$

where e is a row vector with elements being equal to 1, $\bar{y} = p_i' \times y_i^*$ (p_i' the price of outputs and y_i the quantity of outputs). The NPE of the i-th bank is:

$$\mathrm{NPE} = (e\bar{y}_i - e\bar{x}_i)/(e\bar{y}_i^* - e\bar{x}_i^*) \tag{5.25}$$

where $e\bar{y}_i - e\bar{x}_i$ is the observed profit and $e\bar{y}_i^* - e\bar{x}_i^*$ is the maximum profit.

5. Scale Efficiency

As shown in Chapter 2, scale efficiency (SE) can be measured as the ratio of efficiency of constant returns to scale to the efficiency of variable return to scale. Thus the SE for each bank can be calculated using both CRS and VRS. If calculated CE under CRS is different from CE under VRS, then this proves that the firm has scale inefficiency (Coelli et al., 2005). Scale efficiency (SE) is defined as:

$$SE = \frac{CE_{CRS}}{CE_{VRS}} \tag{5.26}$$

where CE_{CRS} is cost efficiency under constant returns to scale and CE_{VRS} is cost efficiency under variable returns to scale.

5.3 Data and Variables: Definition and Measurement

The data used in this study are obtained from the CBJ database and covers the period 1993-2006. Our sample includes all 22 banks[62] (domestic and foreign) operating in Jordan. In total we have 281 observations. The inclusion of foreign banks allows the comparison of efficiency in both foreign and domestic banks. Moreover, as the data come from different kinds of banks (i.e. Islamic, investment and commercial banks), this allows us to identify which kind of banks is more efficient. The data also covers the period both before and after liberalisation: this allows to test the impact of deregulation on the Jordanian banks' efficiency. The total number of banks operating in Jordan (foreign and domestic) was 21 in 1993 and 23 in 2006. Table 5.1 shows the total assets and number of domestic and foreign banks between 1993-2006.

[62] One bank excluded from sample. Iraqi Rafdien bank has not exercised any banking operations since 1990 as result of UN sanctions on Iraq 1993-2003.

Table 5.1 Domestic and foreign banks

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Total Assets (MJOD)[1]	5979	6679	7526	7824	8616	9425	10436	11474	12542	13225	13807	16090	19390	22523
Number of Banks	21	21	21	20	19	21	21	21	21	20	20	23	23	23
Domestic Banks	16	16	16	15	14	14	14	14	14	13	13	13	13	15
Foreign Banks	5	5	5	5	5	5	5	5	5	5	5	8	8	8
Domestic Banks' Assets (MJOD)	5465	6112	6888	7128	7848	8239	9099	10015	11080	11485	12488	14144	17049	19604
Percentage of domestic banks' assets from total assets	0.91	0.92	0.92	0.91	0.91	0.87	0.87	0.87	0.88	0.87	0.90	0.88	0.88	0.87
Foreign Banks' Assets (MJOD).	514	567	638	697	768	1185	1337	1459	1462	1740	1537	1947	2342	2918
Percentage of foreign banks' assets from total assets	0.09	0.08	0.08	0.09	0.09	0.13	0.13	0.13	0.12	0.13	0.10	0.12	0.12	0.13
Percentage of foreign ownership from national banks	0.33	0.32	0.29	0.31	0.45	0.47	0.47	0.48	0.51	0.51	0.51	0.51	0.52	0.55

[1]MJOD: Millions of Jordanian dinar. All values in nominal terms.

5.3.1 Input and Output Variables

After the decision to measure cost and profit efficiency using SFA and DEA, the total costs, net profits, inputs, outputs, input prices and outputs prices need to be determined. When measuring the cost and profit efficiency of multi-product firms such as banks, there are many problems regarding the definition of their inputs and outputs (Maggi and Rossi, 2003). Unlike manufacturing firms, banks' outputs cannot be measured in physical quantities, as a bank is an entity engaged in the intermediation of services between lenders and depositors. Banks also provide a wide array of services, such as low-risk assets, credit and payment services and the running of investment portfolios (Molyneux et al., 1996); fortunately, the literature on banks' efficiency outlines a number of approaches to define their inputs and outputs (see Chapter 3).

This study employs the intermediation approach proposed by Sealey and Lindley (1977), as indicated earlier, for defining bank inputs and outputs. This approach assumes that banks collect deposits to transform them, using labour and capital, into loans, investments and other earning assets (e.g. balances with other banks). As pointed out by Aly et al. (1990), Berger and Mester (1997), Altunbas et al. (2001), Casu and Molyneux (2003), Weill (2004) and Bos et al. (2009), the inputs used in the calculation of the various efficiency measures are funds, labour and physical capital and the outputs used are loans, investments and other earning assets. Table 5.2 shows the descriptive statistics of the Jordanian banks' total costs, net profit, inputs and outputs, price of inputs and price of outputs variables during 1993-2006.

As shown earlier, banks' cost is modelled as a function of input prices and outputs and a set of control variables. Similarly, banks' profit is modelled as a function of input prices, output prices and a set of control variables. Table 5.2 shows total costs, net profit, input prices, output and output prices[63] for Jordanian banks in 1993-2006.

Regarding estimation of the cost stochastic frontier, total cost (TC) will include interest expenses on customers' deposits, banks deposits and cash margins, commission

[63] Total costs, net profit, inputs, outputs, input prices and output prices are obtained from the banks' balance sheets and income statements.

expenses, personnel expenses, depreciation, provision expenses, trading expenses and trading losses, and other expenses related to bank operations.

For estimation of the profit stochastic frontier, net profit (NP)[64] will include interest income from loans, investments, bank deposits, revenue from investments and other revenues related to banking operations, minus total costs.

Input Prices, Outputs and Output Prices

Funds include deposits from banks and financial institutions, customer deposits (demand and current deposits, saving accounts, time and notice deposits and certificate deposits), cash margins and borrowed funds. The price of funds (w1) is calculated, as percentage, by dividing total interest expenses from customer deposits, bank deposits, cash margins and borrowed funds by the average of funds.

Labour relates to the number of full-time employees at a bank and the price of labour (w2) is measured, as millions of JOD, by dividing personnel expenses by the number of employees.

Physical capital includes the book value of premises and equipments and other assets, including prepaid expenses. The price of physical capital (w3) is measured, as percentage, by dividing the depreciation and other non-interest expenses by the average of physical capital.

The three outputs to be used in this study include loans (y1), investments (y2) and other earning assets (y3), measured in millions of JOD dinar. The total customers' loans (y1) include advances and loans, discounted bills and debentures, overdrafts, credit cards and syndicated loans. The price of loans (p1) is measured as percentage by taking the sum of interest income and fees from loans over the average of loans.

[64] As a number of banks in the sample the exhibit negative profits (i.e. losses) and log does not accept negative values, the dependent variable net profit (NP) in the profit model is transformed to $\ln(NP + |(NP)^{min}| + 1)$, where $|(NP)^{min}|$ is the minimum absolute value of NP (i.e. maximum losses) over all banks in sample. This transformation is common in the literature and recommended by Berger and Mester (1997).

Investments (y2) include trading securities, available for sale, held to maturity and investments in associations and affiliates. The price of investment (p2) is measures as percentage of all interest income, dividends and trading profits by the average of investment.

Other earning assets (y3) include balances and deposits in domestic and foreign banks and certificate of deposits issued by Central and other banks. The price of other earning assets (p3) is measured as percentage of all interest income earned from domestic and foreign banks by the average[65] of other earning assets.

In addition to the above variables, this research will also include financial capital (E) (equity) as an additional input, and a time trend (T)[66].

Maudos et al. (2002) argued that the inclusion of financial capital in cost and profit frontier estimation offers many advantages: (i) capital affects costs, because it is a source of funding, other than deposits, that does not generate financial costs, and (ii) capital increases generate more costs than any deposit increases. Also, the inclusion of financial capital allows for the accounting of various risk preferences regarding the operation of banks; thus, if some banks are more risk averse than others, they may hold a higher level of financial capital than maximising profits or minimising costs (Maudos et al., 2002). Berger and Mester (1997) argued that a bank's capital level directly affects costs by providing an alternative to deposits as a funding source for loans. Interest paid on deposits counts as cost, whilst dividends paid to the shareholder are not included in cost. If the financial capital is not included, the estimated efficiency for banks will be under/overestimated (Mester, 1997). Hughes and Mester (2008) argued that financial capital is a part of a bank's production technology and should be included in the estimation of cost and profit functions. Hughes and Mester (1993), Clark (1996), Hughes et al. (1996), Akhavein et al. (1997) , Berger and Mester (1997), Mester (1997), Hao et al. (2001), Maudos et al. (2002) and Delis et al. (2009) are all examples of studies including financial capital in the estimation of the cost and the profit frontiers.

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[65] In calculating input and output prices, the average of inputs and outputs amount was used. The average of inputs and outputs is equal to balance at beginning of the year plus balances at end of the year, divided by 2. An average is used to eliminate the effect of fluctuations throughout year.

[66] Note that financial capital (E) and time trend (T) will be fully interactive with outputs (Y) and input price variables, which will be shown in the model specification.

A time trend (T=1 for 1993, T=2 for 1994,..........T=14 for 2006) is included in the model in order to test for changes in technology over time, regarding estimated costs: Coelli et al. (2005) pointed out that if observations are available over time, the technological changes may be observed by including a time trend within a model. McKillop et al. (1996), Lang and Welzel (1996) and Altunbas et al. (1999) showed that the rate of technical progress may be inferred from changes in a firm's cost function over time. The time-trend (T) is a 'catch-all' variable that captures the effects of technological factors, i.e. learning by doing and organisational changes, allowing for the more efficient use of existing inputs together with the effects of other factors, such as changing environmental regulations (Altunbas et al. 1999). Under technical progress, banks may produce a given output at lower costs over time.

Technical change can be estimated by calculating the variation in total cost due to a given change in technology. This can be measured by the partial derivative of the estimated cost function, in respect of the time trend and can be shown as $\frac{\partial \ln TC}{\partial T}$ (Altunbas et al., 1999).

Table 5.2 Descriptive Statistics of banks' inputs and outputs[1] 1993-2006

Variables	Description				
Dependent Variables		**Mean**	**S.D.**	**Min**	**Max**
TC (MJOD)[2]	Total costs include interest expenses on customers' deposits, bank deposits and cash margins, commission expenses, personnel expenses, depreciation and other expenses.	29	35.6	0.8	218.3
NP(MJOD)	Net profit includes interest income from loans, investments and deposits with banks, revenue from investments and other revenue related to banking work, minus total costs.	7.4	14.3	-14.7	110.6
Independent variables/ Input prices					
W1 (%)	Price of funds equals total interest expenses on customers' deposits, bank deposits and cash margins / average customer deposits per year.	4.4%	1.9%	0.8%	8.9%
W2 (MJOD)	Price of employees' equal total personnel expenses/ number of employees.	0.018	0.01	0.006	0.066
W3 (%)	Price of physical capital (depreciation and other non-interest expenses / average physical capital per year)	1.4%	1%	0.09%	8.2%
Independent variables/ Outputs Quantity					
Y1(MJOD)	Loans include all types of loans net of provision, interest and commission in suspense.	189	218.9	4.8	1372
Y2(MJOD)	Investments include trading securities, available for sale, held to maturity and investment in associations and affiliates	58	113.3	0.2	880.3
Y3(MJOD)	Other earning assets including deposits with domestic and foreign banks.	204.7	364	3.8	2224.3
Independent variables /Outputs Prices					
P1 (%)	Price of loans (total interest and commission income from loans/ average loans per year)	11%	2.7%	0.8%	17.8%
P2 (%)	Price of investments (interest and revenue of investments/ average investments per year)	6.3%	5%	-14%	36.5%
P3 (%)	Price of other earning assets (interest and commissions from banks/ average balances with domestic and foreign banks per year).	5%	2.3%	0	14.3%
Other variables					
E (MJOD)	Banks' financial capital.	52.3	79.4	-17.1	789.6
T	Time trend (T=1 for 1993, T=2 for 1994, ..., T=14 for 2006)			1	14

[1]Figures deflated using GDP deflator and taking 1993 as base year.
[2]MJOD = Millions of Jordanian Dinar. Jordanian Dinar is equal to 1.4 US dollars.

Table 5.2 highlights a large disparity between banks in Jordan, in terms of total cost (TC), net profit (NP) and outputs (for more details of characteristics of Jordanian banks, see Chapter 4). For example, the maximum value of total cost is about 218.3 million JOD, whereas the minimum value is about 0.8 million JOD and the standard deviation around 35.6 million JOD. In terms of input prices, Table 5.2 shows that there is no significant disparity between them, which suggests that input prices are exogenous (i.e. determined by market). However, there is a disparity between output prices (e.g. the SD of loans is 2.7%) amongst banks. This suggests that many banks may have some market power in setting their output prices.

5.3.2 Control and Environmental Variables

The estimation of cost/profit efficiency, using just input and output variables, is based on the assumption that all banks face the same conditions and there are no differences between them. In reality, as shown in Chapter 2, the ability of a manager to convert inputs to outputs varies over time and space, due to internal bank-specific characteristics (e.g. level of risks, ownership structure) and/or external environment factors (e.g. level of competition). These internal and external factors may be exogenous and influence either the production process itself or the efficiency at which a bank operates (Kuenzle, 2005).

Hughes and Mester (2008) argued that inefficiency is derived from the residuals (i.e. u) and thus the selection of the characteristics of the banks and environmental variables to include in the frontier estimation is very important. These variables define the peer group that determines best-practice performance against which a particular bank's performance is judged. Exogenous variables have been incorporated into efficiency measurement models in a variety of ways. In one approach, one may specify a cost/profit function by assuming that the exogenous variables may influence the structure of the cost and profit functions (Kumbhaker and Lovell, 2000). In this specification, the heterogeneity variables (exogenous variables) influence the cost of production directly and alter the shape of the frontier. However, any variation in inefficiency is unexplained by this specification (Kumbhaker and Lovell, 2000). A second approach is where one may specify the cost and profit functions by assuming that the exogenous variables have an influence on the distance that separates each bank from the best practice function (Battese and Coelli, 1995); in other words, the exogenous variables will affect the inefficiency (u_i) in equations (5.4), (5.6) and (5.8). In this study, in addition to the input and output variables, two kinds of variables will be used. The first will be called control variables and we assume that they have a direct influence on the banks' performance. The second are called environmental variables and we assume that these variables have an influence on the inefficiency (u_i).

1. Control Variables

Control variables include bank-specific variables, which may have a direct influence on the position of the frontier (i.e. the frontier shifts down or up) (Coelli, 1999; Bos et al., 2008). The introduction of bank-specific variables allows one to account for heterogeneity between banks, in terms of risks and the quality of banks' output.

Hughes and Mester (2008) argued that estimating the cost or profit functions without taking into account a bank's choice of risk is a serious omission. They also argued a bank's choice of risk is an important part of banking technology and thus should be taken into account when estimating cost/profit functions. Similarly Mester (1993, 1997) and Berger and Mester (1997) argued that a failure to account for heterogeneity among banks is likely to cause biased efficiency scores, with Mester (1997) reporting that some banks may be mislabelled as inefficient because they are operating in a more risk-averse manner than others, whilst others may be mislabelled as efficient because they are producing a lower quality of outputs than others. Control variables enter into the estimation of the bank's cost and profit frontier in the same way as the input and output variables and they fully interact with input prices and outputs in order to reflect the impact of these variables on the input prices and output quantity and on the estimated cost/profit efficiency scores. Table 5.3 shows the control variables included in this study.

Table 5.3 Control Variables

Control Variables	Description	Mean	S.D.	Min.	Max.
C1	Asset quality (loan loss provisions plus interest and commission in suspense / average loans).	10.7%	10.%	0.3%	66.1%
C2	Capital adequacy according to Basel I (equity/risk weighted assets).	10%	6.1%	-16%	68.%

In this research we follow Berger and Mester (1997) and Al-Jarrah and Molyneux (2003) by identifying two control variables. These are the size of loan loss provisions plus interests and commissions in suspense as a percentage of banks' loans (C1) to proxy for the volume on non-performing loans[67] in banks and the capital adequacy ratio (C2) to proxy for the management incentives to take risks.

The volume of non-performing loans in banks can be associated with high risks, bad asset quality and bad management efficiency in follow-up loans granted (Berger and De Young, 1997). Non-performing loans may also be a signal of a misallocation of credit, which may in turn cause a decrease in the funds available for good and safe investments (Dongili and Zago, 2005). Berger and De Young (1997) also indicated that an increase in the volume of non-performing loans was associated with extra costs, such as underwriting provisions and monitoring expenditures: this increases bank costs and in turn decreases profit. Some regulatory authorities impose many restrictions on banks' activities (e.g. prohibiting the granting of new loans) if the non-performing loans exceed a specified ratio and these restrictions may mean that producing a variety of products and services is not allowed, decreasing bank revenue in the process (Mester, 1997). Moreover, many studies (Berger and Humphrey, 1992; Barr and Siems, 1994; De Young and Whalen, 1994; Wheelock and Wilson, 1995) found that banks facing financial distress and thus approaching failure carried a large volume of non-performing loans. Thus, in addition to having a high volume of non-performing loans, failed banks or those approaching failure also tended to have low cost and profit efficiency and poor management quality. Kwan and Eisenbeis (1996) and Resti (1996) found negative relationships between efficiency and non-performing loans. An example of studies where the volume of non-performing loans has been included as a control variable include Hughes et al. (1996), Mester (1996) and Al-Jarrah and Molyneux (2003). However, whether it is appropriate to include non-performing loans in banks' cost/profit functions depends on the extent to which this variable is exogenous (i.e. caused by external variables). This variable could be exogenous if caused by negative economic shocks (bad luck), but it could be endogenous because of bad management. Berger and DeYoung (1997) tested the bad luck and bad management arguments and found mixed evidence on the exogeneity of non-performing loans.

[67] Banks did not report non-performing loans in their financial statements, therefore different studies (e.g. Rao, 2006) use loans' loss provision as proxy for non-performing loans.

With respect to the Jordan banking industry, the problem of non-performing loans could be exogenous as a result of the shocks that faced Jordan during 1990-2003, especially the impacts of the first and second Gulf Wars on the Jordanian economy. As mentioned in Chapter 4, Iraq was the main trading partner of Jordan and many banks granted loans to finance trade between them. After sanctions imposed on Iraq in 1990 by the United Nations, many banks suffered from the non-performing loans' problem because most of the companies and individuals used to dealing with Iraq and already having loans from banks were unable to meet their obligations to them. Thus, we hypothesis that:

Hypothesis 8: Banks with a high percentage of non-performing loans are incurring more costs and generating less profits.

The second control variable included in this study is the capital adequacy ratio (C2), measured according to the Basel I Accord. One of the most important risks that banks face is insolvency (Maudose et al., 2002). The financial capital of banks is viewed as the first line of defence and is used to absorb unexpected loss that banks may face (Basel Committee, 1988). Consequently, the financial capital of banks is subject to prudential capital requirements[68], featuring many objectives. Firstly, to reduce risk-shifting by bankers whose assets are insured. As a result of introducing a deposit insurance scheme, bankers may become involved in more risky activities because they are aware that the deposit insurance company will pay for depositors when the bank goes bankrupt. Thus the existence of a capital adequacy ratio could reduce the attitude of banks towards risks (Rochet, 1992). Secondly, to prevent banks' insolvency and minimise destructive banks (Diamond and Rajan, 2000). Maudos et al. (2002) argued that a bank's insolvency risk is dependent on the composition of its assets and on the financial capital available to absorb any failed investments. Insolvency risk affects a bank's costs and profits through the increase in the prices of its inputs through the risk premium that banks must pay to depositors (Berger and Mester, 1997). The capital adequacy ratio is used by regulatory authorities to determine which banks hold risky assets, and the different attitudes amongst banks regarding risk taking could have a direct impact on the position of the

[68] Regulatory Authorities try to ensure banks have sufficient capital to keep them out of difficulty. Most Regulatory authorities follow Capital Adequacy Requirement specified by the Basel Committee on Banking Supervision called Basel I. Minimum capital requirement that banks should hold is at least 8 % of assets (minimum for Jordan is 12 %). Basel I replaced by Basel II based on three pillars: minimum capital requirement, supervisory review process and market discipline.

cost/profit frontiers. Therefore Hughes and Mester (2008) argued that the estimation of the cost and profit functions without taking into account a bank's choice of risk is a serious mistake. Capital adequacy provides assurance regarding financial soundness against unforeseen contingencies; Delis et al. (2009) found that banks with a high capital adequacy ratio are superior in performance to all other banks, whilst banks with a low capital adequacy ratio seemed to perform the worst. Thus, we hypothesis that:

Hypothesis 9: Banks with low level of capital adequacy are incurring more costs and generating less profit.

Table 5.3 shows that the Jordanian banks are heterogeneous in terms of risk and management quality. For example, the mean for asset quality is 10.7% and the standard deviation is 10.1%, which suggests that some banks faced substantial credit quality problems. Thus the figures in Table 5.3 highlight the importance of including control variables in the cost and profit frontiers, in order to account for heterogeneity among Jordanian banks.

2. Environmental Variables

In this research we follow Berger and Mester (1997), Al-Jarrah and Molyneux (2003) and Bos et al., (2009) to identify the environmental variables that could have an influence on the inefficiency (i.e. u_i) (Battese and Coelli, 1995)[69]. In this study, environmental variables that control banking and market conditions are included: ownership structure (Z1), specialisation (Z2), bank size (Z3), age of bank (Z4), corporate governance (Z5), market structure (Z6), dummy variable for years 1997-2002 (Z7) and dummy variable for years 2003-2006 (Z8). Table 5.4 presents the environmental variables.

[69] Some authors, such as Stevens (2004), mentioned that, in the absence of a convincing theoretical argument with regard to appropriate modelling of exogenous variables in the cost frontier itself or in the determinant of inefficiency, the researcher can try both models and use statistical testing (i.e. log ratio test) to choose the best specification. Coelli et al. (1999) estimated production function by including exogenous variables in the estimation of the production function and in the determinant of inefficiency.

Table 5.4 Environmental Variables 1993-2006

Environmental Variables		Mean	S.D.	Min.	Max.
Z1	Ownership structure (dummy variable equals 1 if bank is foreign or foreign ownership exceeds 50% of bank's capital, otherwise variable = 0).				
Z2	Specialisation: Dummy variable equals 1 if bank is commercial, otherwise equals 0. Dummy variable equals 1 if bank is Islamic, otherwise equals 0. Dummy variable equals 1 if bank is investment bank, otherwise equals 0.				
Z3	Size of bank (total assets) (MJOD[1]).	548.6	788.7	27.4	5127.4
Z4	Age of bank (years)	25 Yrs	18Yrs	0	76Yrs
Z5	Corporate control (dummy variable equals 1 if CEO and Chairman are same person, otherwise equals 0).				
Z6a	Market structure/concentration (Herfindahl index of local market concentration (Z6a) = $\sum_{i=1}^{N}(\frac{x_i}{x})^2$, where x_i is measure of size of deposits of the i-th bank and x represents total deposits for banking sector as a whole.	0.16	0.02	0.12	0.25
Z6b	Market structure/ Market share. (Z6b) = x_i/x, where x_i is measure of size of deposits of the i-th bank, and x represents total deposits for banking sector as a whole.	0.05	0.07	0.002	0.34
Z7	Dummy variable for years 1997-2002 equals 1, otherwise equals 0.				
Z8	Dummy variable for years 2003-2006 equals 1, otherwise equals 0.				

[1]MJOD : Millions of Jordanian dinar. Values in nominal terms.

The first environmental variable is the ownership structure (ownership structure) (Z1), which accounts for the difference of ownership between banks in Jordan, i.e. foreign or domestic. To measure this variable, dummy variables were assigned, equalling 1 for foreign and 0 for non-foreign banks. As mentioned in Chapter 4, there are two types of banks in Jordan, according to ownership structure: foreign and domestic banks. Foreign banks are branches of international banks and are fully owned by foreigners and domestic banks are public ownership banks owned by Jordanians and foreigners.

As shown in Chapter 3, Mahajan et al. (1996) and Chang et al. (1998) argued that foreign banks may possess relative comparative advantages, stemming from different operating strategies, differences in organisational structure and support from home governments. Foreign banks also seem to have a relatively lower cost of funds and operate with a higher capital ratio. Berger et al. (2005) pointed out that foreign banks have an advantage over domestic banks, on the grounds that foreign banks are usually part of large banking organisations and so generally face the same scale economies as large domestically-owned banks. Moreover, foreign banks have better access to the capital market, superior technology and multinational customers, along with a superior ability to diversify risks. Stiglitz (1994) argues that domestic banks may incur extra costs, as they have to compete with large and strong international banks with better management and a better reputation. In addition, foreign banks have better access to cheap funds that are not available to domestic banks. Additionally, in some countries, depositors have little confidence in national banks and they direct their deposits to foreign banks as they provide greater security and confidence. As a result, the domestic banks would have to pay substantially higher interest rates to attract depositors. Stiglitz (1994) also argues that foreign banks are less sensitive to government pressures to finance specific projects that may not be profitable, whereas local banks are more sensitive to such government pressures. On the other hand, foreign banks are subject to some adverse factors that may offset comparative advantages, such as long-distance management, dealing within a more regulatory environment, obtaining inside information (qualitative) about local conditions and a lack of exposure and training within the lesser-known markets (Isik and Hassan, 2003). However, as shown earlier (Chapter 3) many studies have shown foreign banks to be more efficient than domestic banks (Hao et al., 2001; Isik and Hassan, 2002; Harvylchyk, 2006; Kraft et al., 2006).

The second environmental variable used is a dummy variable for specialisation (Z2): there are three different groups of banks operating in Jordan: commercial, investment and Islamic banks, and to see the effects of specialisation on the level of cost and profit efficiency, we assign dummy variables for each group of banks. Commercial banks practise traditional banking activities, such as taking deposits and granting loans; investment banks practise all financial and investment activities, in addition to the brokerage services at the Amman Stock Exchange; and Islamic banks practise all banking, financing and investing on a non-usury basis under Islamic (Shariah) law. Unlike commercial and investment banks, Islamic banks do not have a fixed or predetermined rate of return on financial transactions and they follow Islamic religious restrictions by avoiding any transaction based on interest rates (Hassan, 2005). According to Islamic (Shariah) law, the participants (customers) are allowed to share in business profits and, accordingly, Islamic banks have developed a variety of products based on the participation between the bank and the customer (e.g. equity participation, profit-and-loss sharing[70]) (Isik et al., 2004). Tortosa-Ausina (2004) found specialised banks less efficient (i.e. investment banks), as they produce distinct services and different product mixes requiring a more intense input use and more specialised personnel. Producing different products requires specialised banks to adopt different strategies and adopting these strategies may influence and increase their average cost levels (Maudos and Pastor, 2002). Aly et al. (1990), Ferrier et al. (1993) and Tortosa-Ausina (2003) found that specialised banks are less cost (profit) efficient than commercial banks.

The third environmental variable included is the size of bank proxied by total assets variable (Z3) is included to control for bank size. Within the banking literature, it is considered that bank size should be strongly associated with efficiency, as size may allow of scale of economies. Evanoff and Israilevich (1991) pointed out that larger banks might have a more skilled management team and/or be more cost conscious, due to greater pressure from the owners concerning bottom line profit. Similarly, Casu and Girardone (2006) mentioned that larger banks may have been able to decrease costs by exploiting economies of both scale and scope, achieving market power in their local market and therefore increasing both prices and profits. Berger (1993), Miller and

[70] For more details about Islamic banks' products, see Molyneux and Iqabal (2005).

Noulas (1996), Rangan et al. (1998) and Worthington (1998) all found a positive relationship between bank size and cost/profit efficiency. However, Hermalin and Wallace (1994) and DeYoung and Nole (1996) also found significant negative relationships between bank size and cost and profit efficiency.

The fourth environmental variable is the age of bank (Z4) because It is possible that banking technology inherits learning by doing[71], suggesting that as banks grow older, they could manage their operations better and become more efficient (Isik and Hassan, 2003). Newly established banks may experience higher establishing costs and need time to establish customer relationships (Mester, 1996). Consistent with the 'learning by doing' hypothesis, Mester (1996) found that inefficient banks tended to be newly established (less than 5 years) and Berger and Mester (1997) and Kulasekaran and Shaffer (2002) found a significant positive relationship between efficiency and age. De Young and Hassan (1998) found that during the first three years of operation *de novo* (i.e. banks aged less than 5 years) banks improved their profit efficiency rapidly but on average it took them about nine years to catch up with established banks. On other hand, Isik and Hassan (2003) established a negative relationship between age and efficiency in the Turkish banking market and this was attributed to the older Turkish banks' being strangled by bureaucracy.

The fifth environmental variable relates to corporate control (Z5), included to test the principal-agent problem within Jordanian banks. To measure corporate control within Jordanian banks, a dummy variable is assigned, equal to 1 if the CEO and the chairman are one and the same, otherwise the variable equals 0. As shown in Chapter 2, Fama and Jensen (1983) argued that the principal-agent problem would have a negative impact on a firm's performance unless there is an optimally-devised compensation package or external corporate control mechanism designed to align the objectives of the managers and the shareholders (further details in Chapter 2). The ownership/management relationship is an important element in the operation of banks and the motivation and goals of bank management and stockholders may be a major determinant in the firm's efficiency and performance; such factors may differ widely from one firm to another (Spong et al., 1995). One way to alleviate agency problems is to separate decision

[71] This is a concept in economic theory referring to the capability of workers to improve their productivity and efficiency by regularly repeating same type of action.

management from decision control: the Chief Executive Officer (CEO) of firms generally has the most power regarding decision making, being highly engaged in the preparation of investment projects and their follow-up implementation (Pi and Timme 1993). The Board of Directors, elected by the stockholders and led by the chairman, are assumed to take the role of decision control, setting financial goals and the adoption of written policies that define the criteria and terms for the investment decisions implemented by the CEO. The Board of Directors are also assumed to assess the performance of the CEO and to design and approve the compensation package of key executives (Pi and Timme 1993). Thus, if a CEO is also the chairman of the board, principal-agent conflicts may arise as a result of the concentration of decision management and control within one person. The relationship between separate decision management and decision control and the impact on a bank's efficiency has been analysed by Glassman and Rhodes (1980), Pi and Tommi (1993), Spong et al. (1995), Berger and Hannan (1998), Isik and Hassan (2003). The majority of these studies reported a negative outcome regarding banking efficiency levels when the CEO and the chairman were the same person.

The next environmental variable included involves the market structure (concentration), so the Herfindahl Index (Z6a) and market share (Z6b) control for market structure in accordance with the traditional structure-conduct-performance (SCP) paradigm. With the exception of the case of perfect competition, other market structures show how firms can exercise some kind of market power by setting their prices above a competitive price (more details in Chapter 2). Berger and Hannan (1998) asserted that if high levels of concentration exist in the banking market, this would allow banks to charge prices in excess of competitive levels. Thus, managers will not work as hard to keep costs under control.

The structure-conduct-performance (SCP) model is a general statement of the determinants of market performance. Simply, the conduct or rivalry within the market is determined by market structure conditions, especially the number and size distribution of firms and the conditions of rivalry (Molyneux et al., 1996). There are two SCP hypotheses that can be tested in order to examine the relationship between the market structure and banks' efficiency: the traditional and the efficient hypotheses. The traditional SCP hypothesis asserts that banks in less competitive markets can charge higher prices for their services and eventually make supernormal profits; thus, such banks may feel under less pressure to control their costs. Demsetz (1973) argued that a positive relationship between profit rates and concentration may reflect the differentiated efficiency of the largest and smaller banks within various markets, rather than reflecting a more effective collusion within the more concentrated markets. In other words, by explaining the links between market structure and performance, the efficient structure hypothesis proposes that an industry's structure may arise from superior operating efficiencies by a particular firm. According to this hypothesis, a positive relationship between firms' profit and structure is attributed to the gains made in market share by more efficient firms, leading in turn to increased concentration.

The seventh and eighth environmental variables (Z7) and (Z8) are dummy variables which control for the years 1997-2002 and 2003-2006: these variables are incorporated to capture the effects of the deregulation measures introduced during these two periods (see Table 4.3). In the years 1997 and 2003, there were many important deregulation measures undertaken by the CBJ. In 1997, the maximum limit of 49% on the size of FDI within Jordanian banks was eliminated and the CBJ fully removed all restrictions from the foreign exchange system. This included:

1. Allowing non-resident accounts in Jordanian dinars and or / foreign currency.
2. Allowing resident account holders to maintain an account in foreign currency of any amount.
3. Transferring the value of imports to foreign beneficiaries without CBJ approval.

In 2003, to promote and enhance competition within the Jordanian banking industry, the CBJ allowed three branches of foreign banks to operate in Jordan: these belonged to large financial institutions in the Middle East which had a strong financial position and good risk management practices. The CBJ hoped that their introduction would help to promote competition within the Jordanian banking market and would also motivate the existing banks to operate more efficiently in order to be able to compete with the new banks. To test the effects of the CBJ deregulation processes in these years, we follow Allen and Liu (2005) and assign a dummy variable equal to 1 for years 1997-2002, otherwise equal to zero, and a dummy variable for years 2002-2006 equal to 1, otherwise zero.

5.4 Model(s) Specification

Having decided to estimate cost and profit efficiency and having identified and measured dependent and independent variables[72], the functional form needs be specified (see Chapter 3): this study uses the translog functional form[73] and for the cost function[74] is:

$$
\begin{aligned}
\ln\left(\frac{TC_{it}}{w_3}\right) &= \alpha_0 + \sum_{n=1}^{2}\beta_n \ln(w_{nit}/w_3) + \sum_{k=1}^{3}\delta_k \ln y_{kit} + \varpi_1 \ln E_{it} + \tau_1 T + \sum_{r=1}^{2}\chi_r \ln c_{rit} \\
&+ \frac{1}{2}\left[\sum_{n=1}^{2}\sum_{j=1}^{2}\beta_{nj}\ln(w_{nit}/w_3)\ln(w_{jit}/w_3)\right] + \frac{1}{2}\left[\sum_{k=1}^{3}\sum_{m=1}^{3}\delta_{km}\ln y_{kit}\ln y_{mit}\right] \\
&+ \sum_{n=1}^{2}\sum_{k=1}^{3}\eta_{nk}\ln(w_{nit}/w_3)\ln(y_{kit}) + \frac{1}{2}\left[\varpi_{11}\ln E_{it}^2\right] \\
&+ \sum_{n=1}^{2}\varphi_{1n}\ln E \ln(w_{nit}/w_3) + \sum_{k=1}^{3}\zeta_{1k}\ln E_{it}\ln(y_{kit}) \\
&+ \frac{1}{2}\tau_{11}T^2 + \sum_{k=1}^{3}\kappa_{1k} T \ln y_{kit} + \sum_{n=1}^{2}\theta_{1n} T \ln(w_{nit}/w_3) + \frac{1}{2}\left[\sum_{r=1}^{2}\chi_{rr}\ln c_{rit}^2\right] \\
&+ \sum_{n=1}^{2}\sum_{r=1}^{2}\rho_{nr}\ln(w_{nit}/w_3)\ln(c_{rit}) + \sum_{k=1}^{3}\sum_{r=1}^{2}\omega_{kr}\ln y_{kit}\ln c_{rit} + \ln\varepsilon_{it}
\end{aligned}
\qquad (5.27)
$$

where $\ln TC_{it}$ is the natural logarithm of the total cost of the i-th bank at time t; w_{nit} is the natural logarithm for the input price vectors for the i-th bank at time t (i.e. price of funds (w1), employees (w2) and physical capital (w3)); y_{kit} is the natural logarithm of outputs for the i-th bank at time t (i.e. loans (y1), investment (y2) and other earning assets (y3)); E_{it} is a financial capital of the i-th bank at time t; T is a time trend (T=1 for 1993, T=2 for 1994,...........T=14 for 2006); c_{rit} is a set of control variables for the i-th

[72] Please note the following discussion applies to only (SFA).

[73] Despite translog function forms being most popular in the literature, it has many limitations, especially in estimation of economies of scale (see Chapter 3). These limitations could be overcome by using Fourier-flexible functional form, as suggested by McAllister and McManus (1993). The Main problem with the Fourier flexible form, however, is that there are more parameters to estimate and it requires large numbers of observations to estimate cost and profit efficiency (Maudos and Pastor, 2003; Bakhouche, 2004; Coelli et al., 2005). Moreover, Altunbas and Chakaravarty (2001) indicate that, while the Fourier flexible form is better in terms of goodness of fit, its forecasting ability to generate efficiency scores is worse, which may imply the use of the translog form could be justified by its better predictive ability (Molyneux and Iqbal, 2005). Given the number of observations in this research is 281, use of Fourier flexible form would lead to losing a degree of freedom, which in turn may affect the estimation of efficiency scores.

[74] The Functional form for standard and alternative profit frontiers is same as the functional form of the cost function, except that the dependent variable in equation (5.27) becomes net profit (NP) and the composite error term is $\varepsilon_i = v_i - u_i$.

bank at time t (i.e. asset quality (C1), capital adequacy (C2)); $\varepsilon_{it}=v_{it}+u_{it}$ is a composite error, where v_{it} is a random error which is assumed to be two-sided, usually normally distributed with $v_{it} \sim N(0, \sigma_v^2)$ and independent from u_{it} and the explanatory variables. u_{it} is non-negative errors, which represents an inefficiency and is assumed to be one-sided and independently distributed from v_{it}, whilst α, β, δ, ϖ, τ, χ, η, φ, ζ, κ, θ, ρ and ω are the unknown parameters to be estimated.

Since the cost function is required to be linearly homogeneous in terms of input prices (Coelli et al., 2005) (i.e. an increase in input prices leads to an increase in the total cost of the same proportion), the following restrictions must be applied to the parameters of the cost function in equation (5.27) (Lang and Welzel, 1996) :

$$\sum_{n=1}^{3}\beta_n = 1; \sum_{n=1}^{3}\beta_{nj} = 0; \sum_{n=1}^{3}\theta_{1n} = 0; \sum_{n=1}^{3}\eta_{nk} = 0; \sum_{n=1}^{3}\rho_{nr} = 0$$

Also, the second order parameters of the cost function must be symmetric:

$\delta_{km} = \delta_{mk}$ and $\beta_{nj} = \beta_{jn}$

Therefore, by normalising total costs, price of funds (w1) and price of employees (w2) by price of capital (w3), we impose the theoretical condition that the cost function is linearly homogeneous, in terms of input prices.

As discussed in section 5.3, the control variables (c_r) are included directly in the model to estimate the cost and profit frontiers in the same way as the input and output variables and they fully interact with input prices and output, as reflected in equation (5.27). On the other hand, the environmental variables are assumed to directly affect u_i (inefficiency). Battese and Coelli (1995) developed a model that defines the inefficiency term u_i as a function of a set of environmental variables: they asserted that u_i represents non-negative random variables, which are assumed to account for cost/profit inefficiencies and are also thought to be independently distributed as truncations at zero[75] of the N (m_{it}, σ_u^2) distribution, where:

$$m_{it} = z_{it}\Psi \tag{5.28}$$

where m_{it} is the mean of cost/profit inefficiency (i.e. u_i), z_{it} represents a vector of environmental variables which may influence the inefficiency of the i-th bank at time t, and Ψ is the vector of coefficients to be estimated. In this study, regarding the control of environmental variables, m_{it} in equation (5.30) is defined as:

[75] Half-normal distribution of inefficiency (u_i) truncated at zero to obtain mean difference from zero.

$$m_{it} = \Psi_0 + \Psi_1 z1 + \Psi_2 z2 + \Psi_3 z3 + \Psi_4 z4 + \Psi_5 z5 + \Psi_6 z6 + \Psi_7 z7 + \Psi_8 z8 \qquad (5.29)$$

where z1 is ownership structure, z2 bank specialisation, z3 size of bank, z4 age of bank, z5 corporate control, z6 market structure/concentration/market share, z7 dummy variable for years 1997-2002 and z8 dummy variable for years 2003-2006.

5.4.1 One-Stage Analysis

Some studies explore the relationship between the explanatory variables and predicted efficiency using the two-stage analysis (e.g. Pitt and Lee, 1981; Berger and Mester, 1997; Isik and Hassan, 2003). The first stage involves estimating a conventional frontier with traditional inputs and outputs, while the second stage involves regressing of the predicted cost efficiencies onto the explanatory variables. However, Coelli et al. (1999) have noted that a failure to include firm-specific and environmental variables in the first stage leads to a biased estimation of the estimated parameters of the cost frontier and to biased predictors of cost efficiency. Reifschneider and Stevenson (1991) have identified another problem in second stage analysis: in the first stage, the term u_i is assumed to be independently and identically distributed and, in the second stage, the inefficiencies should vary with control variables c_r and environmental variables z_{it} which contradicts that the u_i should be identically distributed (Coelli et al., 2005). Battese and Coelli (1995) presented models to overcome these problems that estimate the production/cost frontier in one stage, by introducing control (firm-specific variables) and environmental variables directly into the model.

Therefore, to measure the cost and profit efficiency for Jordanian banks (1993-2006), one-stage analysis will be used. Three models will be estimated: cost efficiency (model A), standard profit efficiency (model B) and alternative profit efficiency (model C)[76]. In developing each model, many different models will be estimated and one will then be selected as the preferred model for calculation of the cost and profit efficiency scores for Jordanian banks. The cost and profit frontiers are estimated using the panel data approach[77], as suggested by Battese and Coelli (1995) and for each model there are

[76] The following discussion will centre on cost efficiency estimation; the procedure for estimating profit efficiency is the same.

[77] Panel data sets usually contain more observations than cross-sectional data and thus panel data allow relaxing some of the strong distributional assumptions necessary to disentangle the separate effects of inefficiency and random error and investigate change in efficiency over time (Coelli et al., 2005). The most popular panel models are time-varying and time-invariant. For more details about panel models in estimating cost and profit efficiency, see Kumbhaker and Lovell (2000) and Kuenzle (2005).

several stages before the preferred model is identified. These include estimation of the general model with all control and environmental variables, which will later be compared to other models with different combinations of control and environmental variables. The preferred model will be chosen based on maximum-likelihood tests. Table 5.5 shows the different cost models to be estimated in order to identify the preferred model

Table 5.5 Stages in Identifying Preferred Model

A1 General model includes: Input prices (W1, W2 and W3), outputs (Y1, Y2 and Y3), control variables (C1 and C2), environmental variables (Z1-Z8), equity (E) and time trend (T).
A2 General model with reduced control variables (i.e. C1 and C2) and with environmental variables (Z1-Z8).
A2.1 General model without asset quality (C1) and with environmental variables (Z1-Z8).
A2.2 General model without capital adequacy (C2) and with environmental variables (Z1-Z8).
A3 General model without control variables (i.e. C1 and C2) and with environmental variables (Z1-Z8).
A4 General model with control variables only (C1 and C2) and without environmental variables (Z1-Z8).
A5 General model without control variables (C1 and C2) and without environmental variables (Z1-Z8).

Notes. W1: price of funds, W2: Price of labour, W3: price of physical capital, Y1: loans, Y2: investments, Y3: other earning assets, C1: asset quality, C1: capital adequacy, Z1: ownership structure, Z2: specialization, Z3: size of bank, Z4: age of banks, Z5: corporate control, Z6: market structure, Z7: years 1997-2002 and Z8: years 2003-2006.

5.4.2 Identifying the Preferred Model

Stage A1: Deriving the General Cost Model

This stage estimates the stochastic frontier for the cost function, by assuming that the cost frontier is determined by the banks' outputs (y_k), input prices (w_n), financial capital (E) and bank specific variables/control variables (c_r). Also, in this model, we assume that cost inefficiency (u_i) is a function of a set of environmental variables (z_i). This stage uses the approach suggested by Battese and Coelli (1995), the technical inefficiency model. To estimate this model, equations (5.27) and (5.29) will be used.

After estimating the general model (see Table 5.5a), the model is checked for the existence of inefficiency. As discussed earlier, the composite error terms (ε) consist of a random error (v) and inefficiency (u) and, initially, a check should be made for inefficiency (u) within the composite error (ε). Table 5.5a shows the tests for the general model estimated for the cost frontier of Jordanian banks: column (1) shows the maximum log-likelihood measure and column (2) shows the log-likelihood ratio (LR). The LR provides a check on the assumption of inefficiency in the composite error (ε), while column (3) shows the gamma outcomes (γ). Battese and Corra (1977) parameterised γ as $\frac{\sigma_u^2}{(\sigma_v^2+\sigma_u^2)}$, where σ_u^2 is the variance of the inefficiency and σ_v^2 is the variance of the random error. The γ parameter lies between zero and one and, as discussed earlier, the value of γ provides an indication of the relative contribution of u and v to ε (for example, if γ approaches zero, then the random error (v) dominates the composite error (ε); if γ approaches 1, then the inefficiency (u) dominates the composite error). The null hypothesis to be tested is $H_0 : \gamma = 0$, which implies no inefficiency in the error term (ε). The alternative hypothesis is $H_1 : \gamma \neq 0$, which implies inefficiency exists in the error term(ε). To test this hypothesis, the values of the log-likelihood ratio test (column (2) in Table 5.5a) were used, as produced by frontier 4.1 program, in three steps. In the first step, the Ordinary Least Squares (OLS) estimates of the parameters are obtained and the log likelihood for the OLS is reported. At this stage, the main assumption is that the total error term (ε) consists solely of random error (v) and that σ_u^2 is equal to zero. In the second step, the joint density function of u and v is tested: if the distribution of the total error (ε) is positively skewed (or, in the case of profit, negatively skewed) then the one-sided error component (inefficiency) dominates the random error component in the determination of ε. In the final step, if inefficiency exists in the error term (ε), the log likelihood ratio (LR) of the stochastic model is calculated. The LR test in column (2) is equal to:

$$LR = -2[\ln L_R - \ln L_U] \tag{5.30}$$

where $\ln L_R$ denotes the maximum log likelihood values of the restricted model (the maximum log likelihood for OLS model that is restricted as $\sigma_u^2 = 0$), and $\ln L_U$ denotes the maximum log likelihood values of the unrestricted model (the stochastic model).

Coelli (1995) shows that the LR test is asymptotically distributed as a chi-squared (χ^2) distribution, with the degrees of freedom equal to the number of restrictions imposed. The number of restrictions imposed in the restricted model (i.e. OLS model) is one, i.e. $\sigma_u^2 = 0$. The 5% critical value of χ^2 at one degree of freedom equals 3.84 (see column (5) of Table 5.5a). If the outcome of the LR test (column (2)) exceeds the 5% critical value at the given degree of freedom (column (5)), the null hypothesis of no inefficiency is rejected. If we accept the null hypothesis, it implies that the model cannot follow a stochastic path and therefore should be discarded. As Table (5.5a) shows, the LR (column (2)) of the general model exceeded the 5% critical value at one degree of freedom, leading to the rejection of the null hypothesis of no inefficiency effects: this implies that inefficiency is present in the general model.

Stage A2: Deriving the General Cost Model with Reduced Control Variables (C1 and C2) and with Environmental Variables (Z1-Z8)

As mentioned before, there are two control variables; asset quality (C1) and capital adequacy (C2). At this stage, we estimate the following models:

Model A2.1: General model without asset quality (C1) and with environmental variables (Z1-Z8).

Model A2.2: General model without capital adequacy (C2) and with environmental variables (Z1-Z8).

There are two null hypotheses to be examined:

$H1_0$: The specification of the model without asset quality (C1) is better than that of the general model.

$H2_0$: The specification of the model without capital adequacy (C2) is better than that of the general model.

The alternative hypotheses against the above null hypotheses are that the general model A1 is better specified than models A2.1 and A2.2; equations (5.27) and (5.29) will be used in the estimation.

Stage A3: Deriving the General Cost Model without Control Variables (C1 and C2) and with Environmental Variables (Z1-Z8)

At this stage, the following model is estimated:

Model A3: The general model without control variables (C1 and C2) and with environmental variables (Z1-Z8).

The model will therefore be specified without any control variables and with environmental variables according to equation (5.27) but without C_r variables and equation (5.29).

At this point, the null hypothesis ($H3_0$) to be tested is that the specification of the model without control variables is better than that of the general model A1.

Stage A4: Deriving the General Cost Model with Control Variables (C1 and C2) and without Environmental Variables (Z1-Z8)

At this stage, the following model is estimated:

Model A4: Cost frontier with control variables only.

The cost frontier with control variables is estimated using only equation (5.27). The main assumption is that there are no exogenous factors that affect the banks' inefficiency, but at the same time it is assumed that there is a difference between banks, in terms of asset quality and risk (i.e. C1 and C2). The null hypothesis ($H4_0$) to be tested is that the model with control variables only is better than the general model.

Stage A5: Deriving the General Cost Model without Control Variables (C1 and C2) and without Environmental Variables (Z1-Z8)

This stage estimates the cost frontier by assuming that the cost frontier is determined only by the banks' outputs (y_k), input prices (w_n) and the level of financial capital (E), using equation (5.27) without C_r and Z_i variables.

At this stage, the main assumption is that all banks share the same production technology and face the same environmental conditions. In this case, the null hypothesis ($H5_0$) states that the model excluding control and environmental variables is better than the general model.

As with the general model, all the other model(s) estimated (i.e. A2.1, A2.2, A3, A4 and A5) need to be checked for the presence of inefficiency (u_i) within the composite error term (ε_i). Table 5.5a, Part A, lists all the estimated models and the LR for each model. The null hypothesis is H_0: $\gamma = 0$, which implies no inefficiency in the error term (ε), whereas the alternative hypothesis, $H_1 : \gamma \neq 0$, implies that inefficiency exists in the error term(ε). Following the same procedure (i.e. comparing the LR for each model with the 5% critical value of a χ^2 distribution of one degree of freedom) as used to test the existence of inefficiency in the general model leads to the rejection of the null hypotheses for each model (column 6, Table 5.5a, Part A). That is the inefficiency is presented in all models.

After testing for inefficiency in all models, the next step involves selecting the preferred model. Since there is no convincing theoretical argument for one particular specification over another, Coelli (1996) recommends that when such a decision must be made, the best approach is to estimate many models and the best model is selected using the likelihood ratio statistic (LRS). The process of selecting the 'preferred' model(s) is therefore associated with testing a number of different hypotheses. As mentioned earlier, the modelling process starts by estimating a general model (A1) and this is then compared with the other models (A2-A5), with the 'preferred' model being decided through the maximum-likelihood tests. The log-likelihood provides a convenient way to test the hypotheses in the form of the log-likelihood ratio statistic (LRS), which examines whether a reduced model provides the same or better fit as a general model (Coelli et al., 2005). LRS allows the testing of whether the log-likelihood estimates for the parameters of the reduced model are significantly different from those for the parameters of the general model and the LRS test statistic is given as:

$$LRS = -2(\ln L_{reduced} - \ln L_{unreduced}) \tag{5.32}$$

where $\ln L_{reduced}$ denotes the log-likelihood for the reduced model and $\ln L_{unreduced}$ denotes the log likelihood for the general model. Coelli (1995) shows how the LRS is asymptotically distributed as a chi-squared distribution with the degrees of freedom being equal to the difference in the number of parameters of the general/unreduced model and the reduced models. The null hypothesis to test at every stage is H_0: Model(s) with a reduced number of variables (i.e. control and environmental variables) give(s) a better estimation than the general model (i.e. unreduced model). If the value of the LRS exceeds the 5% critical value of the χ^2 distribution at the given degrees of freedom, we reject the null hypothesis that the reduced model gives a better estimation than the general model. On the other hand, if the LRS is less than the 5% critical value of the χ^2 distribution, the null hypothesis is accepted, which implies that the reduced model gives better estimation than the general/unreduced model. The selection criterion for the 'preferred' model is that the model passes the null hypothesis test (i.e. the coefficients attached to excluded variables are equal to zero). In the case where more than one model passes this test, the preferred model will be the one with the highest log likelihood value (Stevens, 2004). Table 5.5a summarises all models estimated during the process of arriving at the preferred cost model: part B of the table reports the value of the log likelihood ratio statistics (LRS) (column 7), the degrees of freedom (DF) (column 8) and the 5% critical value of the χ^2 distribution at the given degrees of freedom (column 9).

From Table 5.5a and according to the above criteria, the 'preferred' cost model is model A2.2. This model includes one control variable (i.e. asset quality (C1)) and all environmental variables (Z1-Z8). Tables 5.6 and 5.7 report the stages involved in the estimation of the standard and alternative profit models. For standard profit, the 'preferred' model is model B1 (the general model) which includes all control variables (C1 and C2) and all environmental variables (Z1-Z8), and for alternative profit the preferred model is C2.2 which includes one control variable (i.e. C1) and all environmental variables (Z1-Z8).

Table 5.5a Estimated Cost Frontier Models

Part A: Testing for Inefficiency							Part B: Choosing 'Preferred' Model			
Models	(1) Log Likelihood	(2) LR	(3) γ	(4) Number of Restrictions	(5) χ^2 critical value at 5%	(6) Presence of inefficiency $\gamma \neq 0$	(7) LRS	(8) DF	(9) χ^2 critical value at 5%	(10) Decision H_0 = reduced model is better than general model (A1).
A1 General model includes: Input prices (W1, W2 and W3), outputs (Y1, Y2 and Y3), control variables (C1 and C2), environmental variables (Z1-Z8), equity (E) and time trend (T)	379.13	91.42	0.26	1	3.84	yes				
A2 General model with reduced control variables (i.e. C1 and C2) and with environmental variables (Z1-Z8).										
A2.1 General mode without asset quality (C1)	341.43	108.3	1	1	3.84	yes	75.4	7	14.07	Reject
A2.2 General model without capital adequacy (C2)	**372.17**	**139.6**	**0.46**	**1**	**3.84**	**yes**	**13.92**	**7**	**14.07**	**Accept**
A3 General model without control variables (i.e. C1 and C2) and with environmental variables (Z1-Z8)	293.30	95.47	0.96	1	3.84	yes	171.7	14	23.69	Reject
A4. General model with control variables (C1 and C2) and without environmental variables (Z1-Z8)	342.15	17.46	0.99	1	3.84	yes	73.96	10	18.31	Reject
A5 General model without control variables (C1 and C2) and without environmental variables (Z1-Z8)	259.05	26.98	0.99	1	3.84	yes	240.1	24	36.42	Reject

Notes. (1) The log-likelihood: represents a value where the unknown parameters of models are estimated in a way that makes the probability of observing a given data (i.e. total cost) as high (or maximum) as possible. (2) LR (log-likelihood ratio test: is the ratio equals difference of log-likelihood of stochastic frontier minus log-likelihood of OLS estimation multiplied by (-2) and used to test for inefficiency (u) in composite error term (ε) (Coelli, *1995*; Kumbhakar and Lovell, *2000*; Coelli et al., *2005*). (3) $\gamma = \frac{\sigma_u^2}{(\sigma_v^2 + \sigma_u^2)}$. *parameterisation* suggested by Battese and Corra (1977), where σ_u^2 is variance of inefficiency and σ_v^2 is variance of random error. γ-parameter lies between zero and one. Value of γ indicates of *relative contribution* of u and v to ε (i.e. if γ approaching zero, then random error (v) dominates composite error (ε). If γ approaching 1, then inefficiency (u) dominates composite error). (4) The restriction that the composite error term (ε) is consist only from random error (i.e. v) and there is no inefficiency (u).This implies there is 1 restriction, i.e., σ_u=0. (5) LRS log-likelihood of general model (i.e. A1) minus log-likelihood of given reduced model multiplied by (-2). (6) DF degree of freedom which equals number of parameters of general model minus number of parameters of given reduced model.

Table 5.6 Estimated Standard Profit Frontiers Models

Part A: Testing for Inefficiency							**Part B: Choosing 'Preferred' Model**			
Models	(1) Log Likelihood	(2) LR	(3) γ	(4) Number of Restrictions	(5) χ^2 critical value at 5%	(6) Presence of inefficiency $\gamma \neq 0$	(7) LRS	(8) DF	(9) χ^2 critical value at 5%	(10) Decision H_0 = reduced model is better than general model (B1)
B1 General model includes: Input prices (W1, W2 and W3), outputs (Y1, Y2 and Y3), control variables (C1 and C2), environmental variables (Z1-Z8), equity (E) and time trend (T)	**170.76**	**284.3**		**1**	**3.84**	**yes**				
B2 General model with reduced control variables (i.e. C1 and C2) and with environmental variables (Z1-Z8).										
B2.1 General model without asset quality (C1)	159.94	267.0	0.99	1	3.84	yes	20.12	6	12.59	Reject
B2.2 General model without capital adequacy (C2)	122.05	223.1	1	1	3.84	yes	95.9	6	12.59	Reject
B3 General model without control variables (C1 and C2) and with environmental variables (Z1-Z8)	112.69	209.5	0.99	1	3.84	yes	114.6	12	21.03	Reject
B4 General model with control variables (C1 and C2) and without environmental variables (Z1-Z8).	158.97	260.7	0.66	1	3.84	yes	22.06	10	18.31	Reject
B5 General model without control variables (C1 and C2) and without environmental variables (Z1-Z8)	99.3	182.8		0.99	3.84	yes	141.4	22	33.92	Reject

Notes. (1) The log-likelihood: represents a value where the unknown parameters of models are estimated in a way that makes the probability of observing a given data (i.e. total cost) as high (or maximum) as possible. (2) LR (log-likelihood ratio test: is the ratio equals difference of log-likelihood of stochastic frontier minus log-likelihood of OLS estimation multiplied by (-2) and used to test for inefficiency (u) in composite error term (ε) (Coelli, 1995; Kumbhakar and Lovell, 2000; Coelli et al., 2005). (3) $\gamma = \frac{\sigma_u^2}{(\sigma_v^2 + \sigma_u^2)}$ parameterisation suggested by Battese and Corra (1977), where σ_u^2 is variance of inefficiency and σ_v^2 is variance of random error. γ -parameter lies between zero and one. Value of γ indicates of relative contribution of u and v to ε (i.e. if γ approaching zero, then random error (v) dominates composite error (ε). If γ approaching 1, then inefficiency (u) dominates composite error). (4) The restriction that the composite error term (ε) is consist only from random error (i.e. v) and there is no inefficiency (u).This implies there is 1 restriction, i.e., σ_u=0. (5) LRS log-likelihood of general model (i.e. A1) minus log-likelihood of given reduced model multiplied by (-2). (6) DF degree of freedom which equals number of parameters of general model minus number of parameters of given reduced model.

Table 5.7 Estimated Standard Profit Frontiers Models

Part A: Testing for Inefficiency							Part B: Choosing 'Preferred' Model			
Models	(1) Log Likelihood	(2) LR	(3) γ	(4) Number of Restrictions	(5) χ^2 critical value at 5%	(6) Presence of inefficiency $\gamma \neq 0$	(7) LRS	(8) DF	(9) χ^2 critical value at 5%	(10) Decision H_0= reduced model is better than general model (B1)
C1 General model includes: Input prices (W1, W2 and W3), outputs (Y1, Y2 and Y3), control variables (C1 and C2), environmental variables (Z1-Z8), equity (E) and time trend (T)	83.11	224.6	0.99	1	3.84	yes				
C2 General model with reduced control variables (i.e. C1 and C2) and with environmental variables (Z1-Z8).										
C2.1 General model without asset quality (C1)	53.34	210.2	0.75	1	3.84	yes	59.5	7	14.07	Reject
C2.2 General model without capital adequacy (C2)	**76.49**	**229.9**	**0.66**	**1**	**3.84**	**yes**	**13.24**	**7**	**14.07**	**Accept**
C3 General model without control variables (C1 and C2) and with environmental variables (Z1-Z8)	48.77	210.5	0.99	1	3.84	yes	68.68	14	23.69	Reject
C4 General model with control variables (C1 and C2) and without environmental variables (Z1-Z8).	43.69	145.8	0.99	1	3.84	yes	78.8	10	18.31	Reject
C5 General model without control variables (C1 and C2) and without environmental variables (Z1-Z8)	11.93	136.8	0.65	1	3.84	yes	142.4	24	36.42	Reject

Notes. (1) The log-likelihood: represents a value where the unknown parameters of models are estimated in a way that makes the probability of observing given data (i.e. total cost) as high (or maximum) as possible. (2) LR (log-likelihood ratio test: is the ratio equals difference of log-likelihood of stochastic frontier minus log-likelihood of OLS estimation multiplied by (-2) and used to test for inefficiency (u) in composite error term (ε) (Coelli, 1995; Kumbhakar and Lovell, 2000; Coelli et al., 2005). (3) $\gamma = \frac{\sigma_u^2}{(\sigma_v^2 + \sigma_u^2)}$ parameterisation suggested by Battese and Corra (1977), where σ_u^2 is variance of inefficiency and σ_v^2 is variance of random error. γ -parameter lies between zero and one. Value of γ indicates of relative contribution of u and v to ε (i.e. if γ approaching zero, then random error (v) dominates composite error (ε). If γ approaching 1, then inefficiency (u) dominates composite error). (4) The restriction that the composite error term (ε) is consist only from random error (i.e. v) and there is no inefficiency (u).This implies there is 1 restriction, i.e., σ_u=0. (5) LRS log-likelihood of general model (i.e. A1) minus log-likelihood of given reduced model multiplied by (-2). (6) DF degree of freedom which equals number of parameters of general model minus number of parameters of given reduced model.

Finally, it should be noted that there are many models which were estimated by excluding the time trend variable (T). In all such models, the null hypothesis that the estimated models without the time trend are better than the general model was rejected: this suggests that there is technological change within the Jordanian banking market and that the time trend should appear in the model to account for this. In addition, the model(s) without financial capital (E) was also estimated and the hypothesis that this model(s) is better specified than the general model was rejected. Moreover, it should be noted that there is another model, known as Battese and Coelli's (1992) time variant and invariant approach. Under the time invariant approach, the inefficiency (u) is assumed to be constant through time, while under the time variant approach the inefficiency is assumed to change through time. This model allows some flexibility in the distribution of inefficiency (u_i) and allows estimation of the stochastic frontier by using truncated or half-normal distribution (Coelli et al., 2005). It also allows the examination of the time-varying efficiency model against the time-invariant model. The main limitation of Battese and Coelli's (1992) model is that it does not allow for any change in the rank ordering of firms over time; the firm ranked n-th at the first period is always ranked n-th for all periods (Coelli et al., 2005). Battese and Coelli (1995) suggested that the 1992 model did not account for those situations in which some firms were relatively inefficient initially but subsequently become substantially more efficient. Also, this model does not allow the adding of environmental variables. The Battese and Coelli (1992) model was estimated in this research, but the results are not reported because there is no statistical test that can be used to compare Battese and Coelli (1995) and (1992): the two models are not nested. Due to the disadvantages of Battese and Coelli (1992), only the results of Battese and Coelli's (1995) model were used to measure efficiency scores for Jordanian banks.

5.5 Conclusion

This chapter presented the data and the variables measurement. The three types of variables used are: (1) Traditional input prices and outputs used in the literature to estimate cost and profit functions by using the intermediation approach. (2) Control variables to account for the factors that may affect the estimated cost/profit functions and (3) Environmental variables that could have an impact on the levels of inefficiency.

This chapter showed two methodologies used in this research: the SFA and DEA. Three concepts offer a definitional framework for the testing of cost and profit efficiency in the banking industry: cost efficiency, standard profit efficiency and alternative profit efficiency; these were used in this chapter. With regard the SFA methodology, the translog functional form is identified to estimate cost and profit functions. The process of obtaining a preferred cost/profit model from SFA follows recent banking efficiency literature by using one-stage analysis. The choice of models to measure cost and profit efficiency scores was determined using maximum likelihood estimates and the log-likelihood test. Various models of cost and profit frontiers are estimated with different combinations of control variables and environmental variables and the preferred models were chosen according to the log-likelihood ratio test, as recommended by Coelli et al. (2005). The general model without capital adequacy and environmental variables is the preferred cost model. With regard profit models, the preferred model of standard profit is the general model including asset quality and capital adequacy and all environmental variables, whilst the preferred model of alternative profit is the general model without capital adequacy and with environmental variables. With regard DEA estimation the input and output variables only used in the estimation because the DEA methodology does not allow for using control and environmental variables directly in the model

In the next chapter, some properties of the cost and profit functions as identified by economic theory will be tested using the SFA preferred models. Additionally, the research hypotheses outlined in Chapters 4 and 5 will be tested using the preferred cost and profit models. Moreover, the next chapter will analysis the efficiency scores obtained from SFA and DEA in terms of trend of efficiency scores 1n 1993-2006, to examine how the deregulation processes affected on the level of Jordanian banks' efficiency over the period 1993-2006.

Chapter 6 Analysis and Discussion

6.1 Introduction

Chapter 4 reviewed the deregulation measures introduced by the CBJ between 1993-2006 and Chapter 5 explained the different methodologies used to measure efficiency scores for Jordanian banks over this time period. Moreover, Chapter 5 also showed the different stages followed to identify the preferred cost and profit models using the SFA methodology. In this chapter, the preferred SFA models identified in Chapter 5 will be used to derive the cost and profit efficiency scores for Jordanian banks after some of the properties of the cost and profit frontiers are analysed to ensure that the estimated cost and profit frontiers are satisfy the main theoretical requirements outlined in Chapter 2. That is, this chapter will examine the maximum likelihood parameters' estimation of the preferred cost, standard profit and alternative profit frontiers and from these, the main properties of the cost and profit functions will be analysed and many of the research hypotheses (see Chapter 4) will be tested. Additionally, this chapter (i) analyses the efficiency scores obtained from SFA and DEA, (ii) shows how the efficiency scores have changed over time and (iii) tests the robustness of the efficiency scores obtained from SFA and DEA. The main characteristics of the more and less efficient banks; scale efficiency and technological change in Jordanian banks will be also examined.

This chapter therefore is organised as follows. Section 6.2 tests the coefficients of the SFA preferred cost and profit frontier models and the maximum likelihood parameters' estimated will be reported. From these the main properties of the cost and profit frontiers (see Chapter 2) will be analysed. Section 6.3 tests research hypotheses 2-7 outlined in Chapter 4 using the preferred SFA cost and profit frontiers identified in section 6.2. Section 6.4 presents the cost and profit efficiency scores obtained from both SFA and DEA and analyses the trend of the efficiency scores between 1993-2006 to examine how the efficiency scores have reacted to different policies applied by the CBJ. This analysis will also give (i) an indication of the extent to which steps taken by the CBJ have affected, positively or negatively, the banks' efficiency levels and (ii) test the main research hypothesis (see Chapter 4) that the efficiency of banks in Jordan improved after the implementation of liberalisation. Section 6.5 presents a robustness check between the SFA and the DEA efficiency scores, based on the Bauer et al. (1998)

criteria. Section 6.6 analyses the difference between the more and less efficient banks in terms of: the CAMEL rating system; specialisation; ownership structure; and bank size. Section 6.7 shows change in scale efficiency for Jordanian banks and technological change in Jordanian banks over the period 1993-2006.

6.2 Testing the Coefficients of the Preferred SFA Model(s)

The maximum likelihood estimates for the preferred SFA cost, alternative and standard profit frontiers models are reported in Tables 6.1, 6.2 and 6.3. However, the interpretation of the maximum likelihood estimates for the cost and profit models requires more attention, given that there are many interactions between the input prices, the outputs and the control variables. Coelli (1996), Worthington (1998) and Bos et al. (2005) highlight that when variables interact, care should be taken in the interpretation of an individual coefficient's significance, as the inclusion of squared and interaction terms is likely to result in multicollinearity[78], contributing to an artificially high standard error. In general, with these caveats in mind, as total costs, profits and all independent variables are in logarithms and normalised by their mean[79], the estimated first order coefficients can be interpreted as cost and profit elasticities evaluated at the sample mean.

6.2.1 Coefficients of the Preferred Cost Frontier

According to the selection criteria discussed in Chapter 5 (see Table 5.5), the preferred cost frontier model included asset quality (C1) but excluded capital adequacy (C2). The t-ratios for the preferred cost frontier (see Table 6.1), which defines the ratio of the estimated coefficients to their corresponding standard errors, indicates that the coefficients of banks' input prices and outputs are highly significant and positive. This suggests that the theoretical requirements of the cost function are fulfilled (see cost function properties in Chapter 2). Table 6.1 shows that the coefficients of inputs prices are positive and highly significant and the estimated coefficients of input prices are ($\beta 1$)

[78] When multicollinearity occurs as a result of interaction between variables, maximum likelihood estimates are still unbiased and efficient. The problem with multicollinarity is that the estimated error of the coefficient tends to be large, leading to a small value of the t-ratio which in turn will lead to accepting null hypothesis that coefficient is equal to zero (for more details, see Gujarati, 2003).

[79] Since mean values of variables are regarded as expansion point for translog function, all variables have to be divided by their mean in order to locate correct evaluation point before estimation of translog function. In addition, this will help in estimation of scale elasticities.

(i.e. coefficient of price of funds) and (β2) (i.e. coefficient of price of labour) representing the share of cost attributed to funds (deposits) and employees[80]. The coefficients of the input prices w1 (price of funds), w2 (price of labour) and w3 (price of physical capital) are equal to 0.614, 0.122 and 0.264, respectively, which means that, on average, a 1% increase in input prices will increase the cost by 0.614%, 0.122% and 0.264%, respectively (property number 2 in Chapter 2). The magnitude of the coefficient of the price of funds (w1) reflects the actual data, where the price of funds forms about 50% to 70% of the total costs of the Jordanian banks. The outputs (y_k) coefficients show that, on average, a 1% increase in outputs y1 (loans), y2 (investments) and y3 (other earning assets) will increase costs by 0.398%, 0.083% and 0.473%, respectively (property number 3 in Chapter 2). Equity (E) is introduced in the model as an additional input as a source of funding, but the coefficient of equity is only 0.023 and is not significant; this suggests that the level of equity in Jordanian banks does not have a significant impact on banks' costs. A possible explanation of this is that Jordanian banks depended on deposits more than equity to finance their operations, as the raising of equity typically involves higher costs[81] than the raising of deposits (Berger and Mester, 1997). With regard to the time trend (T), the coefficient of time is negative (-0.02) and highly significant at 1%. This means that a technological change has occurred within the Jordanian banking market and through technical progress, Jordanian banks have over time been able to produce a given output at lower levels of cost. With regard to property number 4 in Chapter 2, which relates to homogeneity (i.e. an increase in input prices leads to an increase in the total cost of the same proportion), this property is fulfilled by imposing restriction on the parameters of input prices being equal to unity before estimation (i.e. β1+ β2+ β3=1).

[80] Since the price of funds (w1) and the price of labour (w2) are normalised by the price of physical capital (w3) to impose homogeneity of degree one. The coefficient of physical capital (w3) is equal to 1 minus sum of the coefficients of the price of funds and the price of labour. Thus coefficient of the price of capital equals 1- 0.614+ 0.122= 0.264.

[81] The main costs of raising new equities include fees charged by investment banks in the underwriting processes, fees paid to advisers, accountants and lawyers in preparing the issue, initial listing fees and marketing costs.

Table 6.1 The Maximum Likelihood Parameters for the Preferred Cost Frontier

Parameters	Variables	Coefficients	Standard error	t-ratio[1]
α_0	constant	(-0.155)*	0.032	-4.812
β_1	$\ln\frac{w1}{w3}(\frac{\text{price of funds}}{\text{price of physical capital}})$	(0.614)*	0.040	15.382
β_2	$\ln\frac{w2}{w3}(\frac{\text{price of labour}}{\text{price of physical capital}})$	(0.122)*	0.033	3.680
δ_1	lny1 (loans)	(0.398)*	0.051	7.880
δ_2	lny2 (investments)	(0.083)*	0.024	3.420
δ_3	lny3 (other earning assets)	(0.473)*	0.037	12.721
ϖ_1	lnE (equity)	(0.023)	0.061	0.370
β_{11}	$0.5(\ln\frac{w1}{w3})^2$	(0.250)*	0.045	5.570
$\beta 12$	$(\ln\frac{w1}{w3})(\ln\frac{w2}{w3})$	(-0.106)*	0.041	-2.596
β_{22}	$0.5(\ln\frac{w2}{w3})^2$	(0.126)*	0.041	3.093
δ_{11}	$0.5(\text{lny1})^2$	(0.200)*	0.038	5.325
δ_{12}	(lny1)(lny2)	(-0.040)**	0.019	-2.093
δ_{13}	(lny1)(lny3)	(-0.210)*	0.031	-6.784
δ_{22}	$0.5(\text{lny2})^2$	(0.007)	0.013	0.572
δ_{23}	(lny2)(lny3)	(0.040)*	0.017	2.379
δ_{33}	$0.5(\text{lny3})^2$	(0.202)*	0.032	6.224
η_{11}	$(\ln\frac{w1}{w3})(\text{lny1})$	(-0.003)	0.029	-0.113
η_{12}	$(\ln\frac{w1}{w3})(\text{lny2})$	(-0.002)	0.018	-0.085
η_{13}	$(\ln\frac{w1}{w3})(\text{lny3})$	(-0.010)	0.028	-0.353
η_{21}	$(\ln\frac{w2}{w3})(\text{lny1})$	(0.066)*	0.027	2.422
η_{22}	$(\ln\frac{w2}{w3})(\text{lny2})$	(-0.028)**	0.017	-1.683
$\eta 23$	$(\ln\frac{w2}{w3})(\text{lny3})$	(0.035)***	0.029	1.204

(continued)

Table 6.1 The Maximum Likelihood Parameters for the Preferred Cost Frontier (continued)

Parameters	Variable	coefficients	standard error	t-ratio
ϖ_{11}	$0.5(\ln E)^2$	(0.108)*	0.033	3.253
φ_{11}	$(\ln\frac{w1}{w3})(\ln E)$	(-0.034)	0.047	-0.725
φ_{21}	$(\ln\frac{w2}{w3})(\ln E)$	(-0.029)	0.053	-0.541
ζ_{11}	$(\ln y1)(\ln E)$	(-0.041)	0.040	-1.009
ζ_{21}	$(\ln y2)(\ln E)$	(0.030)	0.029	1.050
ζ_{31}	$\ln y3 \ln E$	(-0.073)**	0.043	-1.684
τ_1	t (time trend)	(-0.019)**	0.008	-2.293
τ_{11}	$0.5(t)^2$	(0.001)	0.001	0.706
κ_1	$\ln(y1)(t)$	(0.011)**	0.005	2.195
κ_2	$\ln(y2)(t)$	(-0.003)***	0.003	-1.279
κ_3	$\ln(y3)(t)$	(0.000)	0.004	-0.083
θ_1	$\ln(\frac{w1}{w3})(t)$	(0.005)	0.005	1.095
θ_2	$\ln(\frac{w2}{w3})(t)$	(0.000)	0.004	0.121
χ_1	lnc1 (asset quality)	(0.033)***	0.022	1.465
χ_{11}	$0.5(\ln c1)^2$	(0.018)**	0.010	1.733
ρ_{11}	$\ln(\frac{w1}{w3})(\ln c1)$	(0.047)*	0.017	2.832
ρ_{21}	$\ln(\frac{w2}{w3})(\ln c1)$	(-0.033)**	0.015	-2.208
ω_{11}	$\ln(y1)(\ln c1)$	(-0.003)	0.016	-0.179
ω_{21}	$\ln(y2)(\ln c1)$	(-0.048)*	0.009	-5.240
ω_{31}	$\ln(y3)(\ln c1)$	(-0.013)	0.015	-0.869
χ_2	lnc2 (capital adequacy)			
χ_{22}	$0.5(\ln c2)^2$			
ρ_{12}	$\ln(\frac{w1}{w3})(\ln c2)$			
ρ_{22}	$\ln(\frac{w2}{w3})(\ln c2)$			

(continued)

Table 6.1 The Maximum Likelihood Parameters for the Preferred Cost Frontier (continued)

Parameters	Variables	Coefficients	Standard error	t-ratio
ω_{12}	ln(y1)(lnc2)			
ω_{22}	ln(y2)(lnc2)			
ω_{32}	ln(y3)(lnc2)			
Ψ	constant	(0.469)	0.588	0.796
Ψ_1	Ownership Structure (Z1)	(-0.143)*	0.028	-5.061
Ψ_{2b}	Islamic (Z2b)	(0.203)*	0.043	4.737
Ψ_{2c}	Investment (Z2c)	(0.318)	0.581	0.547
Ψ_3	Total assets (Z3)	(-0.134)*	0.031	-4.296
Ψ_4	Age of bank (Z4)	(0.010)*	0.001	9.511
Ψ_5	Corporate control (Z5)	(0.028)	0.024	1.181
Ψ_{6a}	Market structure/ concentration (Z6a)	(-0.015)	0.017	-0.900
Ψ_{6b}	Market structure/ market share (Z6b)	(-0.07)*	0.02	-3.488
Ψ_7	Years 1997-2002 (Z7)	(-0.032)	0.028	-1.119
Ψ_8	Years 2003-2006 (Z8)	(-0.083)**	0.045	-1.841
σ^2		(0.006)*	0.001	8.442
γ		(0.457)*	0.079	5.784
log-likelihood	372.17			
LR	139.57			
No. of observations	281			
Degrees of freedom[2]	230			

[1]t-ratio defines the ratio of the estimated coefficients to the corresponding standard errors.

[2]Degrees of freedom equals the number of observations in the sample minus the number of estimated coefficients in maximum likelihood model (i.e. 281-51=230).

*, **, *** significance of parameters of coefficients at 1%, 5% and 10% levels using the t-distribution table and the t-ratios obtained at the given degrees of freedom (i.e. 230). The Critical value of the t-ratios at significance levels of 1%, 5% and 10% are 2.326, 1.645 and 1.282, respectively.

6.2.2 Coefficients of the Preferred Standard and Alternative Profit Frontiers

Again using SFA, Tables 6.2 and 6.3 report the preferred standard and alternative profit models. According to the selection criteria discussed in Chapter 5 (see Tables 5.6 and 5.7), the preferred model of standard profit includes all the control variables (i.e. asset quality (C1) and capital adequacy (C2)), whilst the preferred alternative profit model excluded capital adequacy (C2). As with the cost model, we first checked the coefficients of estimated alternative and standard profit frontiers and, in contrast to the cost model, the results for the alternative and standard models showed some unexpected signs for the coefficient of the price of funds (β_1). The expected sign for β_1 should be negative (i.e. an increase in the price of funds should decrease profit) but the sign obtained in the model is positive (i.e. 0.14 for standard profit model and 1.24 for alternative profit model), which means that an increase in the price of funds (w1) leads to increase in profits. Seemingly surprising result could be explained with reference to the effect of increases in interest rates on deposits. That is as Humphrey and Pulley (1997) suggested that when interest rates on deposits rise the banks respond by increasing the interest rates on loans proportionally more than the increase in deposit interest rates. For other input/output prices and outputs, the signs are consistent with the theoretical requirements of the profit function. For example, the coefficients of output prices in Table 6.2, δ_1 (i.e. the coefficient of the price of loans) and δ_2 (i.e. the coefficient of the price of investments) represent the share of profits attributed to loans and investment[82]. Coefficients of output prices p1(price of loans), p2 (price of investments) and p3 (price of other earning assets) are equal 0.05, 0.74 and 0.21 respectively, showing that, on average, a 1% increase in output prices will increase profits by 0.05%, 0.74% and 0.21, respectively. The coefficients for outputs y1 (loans), y2 (investments) and y3 (other earning assets) in the alternative profit frontier model (Table 6.3) suggest that, on average, a 1% increase in outputs y1, y3 and y3 will increase profits by 0.05%, 0.14% and 0.11%, respectively. Both the standard and the alternative profit models have a positive and significant coefficient for equity (E) (i.e. 0.34 for the standard profit model and 0.29 for the alternative profit model). This would suggest that banks with higher equity can achieve more profits because banks with more equity are capable of

[82] Since price of loans (p1) and price of investments (p2) are normalised by price of other earning assets (p3) to impose homogeneity of degree one. The coefficient of other earning assets (p3) is equal to 1 minus sum of coefficients of price of loans and the price of investments. Thus coefficient of price of other earning assets equals 1- 0.05+ 0.74= 0.21.

producing more outputs, which in turn increases their profits. Both the alternative and the standard profit models show that the coefficient of the time trend (T) is negative and significant (i.e. -0.05 for the standard profit model and -0.14 for the alternative profit model). This suggests that over time the profit efficiency of Jordanian banks has worsened and they have been achieving lower level of profit for any given level of output.

Table 6.2 The Maximum Likelihood Parameters Estimation for the Preferred Standard Profit

Parameters	Variables	Coefficients	Standard error	t-Ratio[1]
α_0	constant	(0.08)***	0.05	1.53
β_1	$\ln\frac{w1}{w3}(\frac{\text{price of funds}}{\text{price of physical capital}})$	(0.14)**	0.07	2.07
β_2	$\ln\frac{w2}{w3}(\frac{\text{price of labour}}{\text{price of physical capital}})$	(-0.03)	0.06	-0.51
δ_1	$\ln\frac{p1}{p3}(\frac{\text{price of loans}}{\text{price of other earning assets}})$	(0.05)	0.11	0.44
δ_2	$\ln\frac{p2}{p3}(\frac{\text{price of investment}}{\text{price of other earning assets}})$	(0.74)*	0.10	7.55
ϖ_1	lnE (equity)	(0.34)*	0.06	5.80
β_{11}	$0.5(\ln\frac{w1}{w3})^2$	(0.06)	0.07	0.85
β_{12}	$(\ln\frac{w1}{w3})(\ln\frac{w2}{w3})$	(-0.08)**	0.05	-1.54
β_{22}	$0.5(\ln\frac{w2}{w3})^2$	(0.09)**	0.05	1.89
δ_{11}	$0.5(\ln\frac{p1}{p3})^2$	(0.34)*	0.10	3.43
δ_{12}	$(\ln\frac{p1}{p3})(\ln\frac{p2}{p3})$	(-0.37)*	0.06	-6.39
δ_{13}	$0.5(\ln\frac{p2}{p3})^2$	(0.38)*	0.04	8.98
η_{11}	$(\ln\frac{w1}{w3})(\ln\frac{p1}{p3})$	(-0.10)	0.08	-1.21
η_{12}	$(\ln\frac{w1}{w3})(\ln\frac{p2}{p3})$	(0.27)*	0.06	4.23
η_{13}	$(\ln\frac{w2}{w3})(\ln\frac{p1}{p3})$	(0.02)	0.08	0.32
η_{21}	$(\ln\frac{w2}{w3})(\ln\frac{p2}{p3})$	(-0.22)*	0.05	-4.04
ϖ_{11}	$0.5(\ln E)^2$	(0.13)*	0.05	2.40
φ_{11}	$(\ln\frac{w1}{w3})(\ln E)$	(0.10)**	0.04	2.23
φ_{21}	$(\ln\frac{w2}{w3})(\ln E)$	(-0.04)	0.05	-0.86
ζ_{11}	$(\ln\frac{p1}{p3})(\ln E)$	(-0.07)	0.09	-0.72

(continued)

Table 6.2 The Maximum Likelihood Parameters Estimation for the Preferred Standard Profit (continued)

Parameters	Variables	Coefficients	Standard error	t-Ratio[1]
ζ_{21}	$(\ln \frac{p2}{p3})(\ln E)$	(0.11)***	0.07	1.56
T_1	t (time trend)	(-0.05)*	0.02	-3.28
τ_{11}	$0.5(t)^2$	(0.01)*	0.00	4.56
κ_1	$\ln(\frac{w1}{w3})(t)$	(-0.03)*	0.01	-3.28
κ_2	$\ln(\frac{w2}{w3})(t)$	(0.02)*	0.01	2.53
κ_3	$\ln(\frac{p1}{p3})(t)$	(0.03)*	0.01	2.69
θ_1	$\ln(\frac{p2}{p3})(t)$	(-0.02)**	0.01	-2.09
χ_1	lnc1 (asset quality)	(-0.13)*	0.03	-3.90
χ_{11}	$0.5(\ln c1)^2$	(0.02)	0.02	0.87
ρ_{11}	$\ln(\frac{w1}{w3})(\ln c1)$	(0.01)	0.03	0.29
ρ_{21}	$\ln(\frac{w2}{w3})(\ln c1)$	(0.03)	0.02	1.27
ω_{11}	$\ln(\frac{p1}{p3})(\ln c1)$	(0.08)***	0.05	1.63
ω_{21}	$\ln(\frac{p2}{p3})(\ln c1)$	(-0.09)**	0.04	-1.94
χ_2	lnc2 (capital adequacy)	(-0.15)	0.13	-1.16
χ_{22}	$0.5(\ln c2)^2$	(0.77)*	0.18	4.15
ρ_{12}	$\ln(\frac{w1}{w3})(\ln c2)$	(-0.21)**	0.11	-1.91
ρ_{22}	$\ln(\frac{w2}{w3})(\ln c2)$	(-0.02)	0.10	-0.20
ω_{12}	$\ln(\frac{p1}{p3})(\ln c2)$	(0.24)***	0.17	1.42
ω_{22}	$\ln(\frac{p2}{p3})(\ln c2)$	(0.06	0.17	0.37
Ψ_0	Constant	(-5.75)*	0.90	-6.38
Ψ_1	Ownership Structure (Z1)	(-0.12)*	0.22	-0.545
Ψ_{2b}	Islamic (Z2b)	(-1.44)*	0.61	-2.38
Ψ_{2c}	Investment (Z2c)	(-0.50)	0.82	-0.61
Ψ_3	Total assets (Z3)	(1.00)*	0.08	12.55

(continued)

Table 6.2 The Maximum Likelihood Parameters Estimation for the Preferred Standard Profit Frontier (continued)

Parameters	Variables	Coefficients	Standard error	t-Ratio[1]
Ψ_4	Age of bank (Z4)	0.03	0.01	5.68
Ψ_5	Corporate control (Z5)	(-0.35)**	0.17	-2.01
Ψ_{6a}	Market structure/ concentration (Z6a)	(-2.93)*	0.99	-2.95
Ψ_{6b}	Market structure/ market share (Z6b)	(-10.84)*	1.54	-7.04
Ψ_7	Year 1997-2002 (Z7)	(-0.21)	0.36	-0.59
Ψ_8	Year 2003-2006 (Z8)	(-0.86)*	0.15	-5.84
σ^2		(0.49)*	0.08	5.89
γ		(0.99)*	0.00	485.67
log-likelihood	170.76			
LR	284.29			
No. of observations	281			
Degrees of freedom[2]	233			

[1]t-ratio defines the ratio of the estimated coefficients to the corresponding standard errors.
[2]Degrees of freedom equals the number of observations in the sample minus the number of estimated coefficients in maximum likelihood model (i.e. 281-48=233).
*, **, *** significance of parameters at 1%, 5% and 10% levels, using the t-distribution table and the t-ratios obtained at the given degrees of freedom (i.e. 233). The critical values of the t-ratios at significance levels of 1%, 5% and 10% are 2.326, 1.645 and 1.282, respectively.

Table 6.3 The Maximum Likelihood Parameters Estimation for the Preferred Alternative Profit

Parameters	Variables	Coefficients	Standard error	t=ratio[1]
α_0	constant	(0.12)*	0.04	3.21
β_1	$\ln\frac{w1}{w3}(\frac{\text{price of funds}}{\text{price of physical capital}})$	(1.24)*	0.04	28.00
β_2	$\ln\frac{w2}{w3}(\frac{\text{price of labour}}{\text{price of physical capital}})$	(-0.12)*	0.05	-2.71
δ_1	lny1 (loans)	(0.05)	0.06	0.73
δ_2	lny2 (investments)	(0.14)*	0.05	2.80
δ_3	lny3 (other earning assets)	(0.11)*	0.05	2.47
ϖ_1	lnE (equity)	(0.29)*	0.09	3.24
β_{11}	$0.5(\ln\frac{w1}{w3})^2$	(-0.38)*	0.06	-5.85
β_{12}	$(\ln\frac{w1}{w3})(\ln\frac{w2}{w3})$	(0.20)*	0.05	3.78
β_{22}	$0.5(\ln\frac{w2}{w3})^2$	(-0.10)**	0.06	-1.70
δ_{11}	$0.5(\ln y1)^2$	(0.09)***	0.06	1.62
δ_{12}	$(\ln y1)(\ln y2)$	(0.05)**	0.03	1.73
δ_{13}	$(\ln y1)(\ln y3)$	(-0.14)*	0.05	-2.79
δ_{22}	$0.5(\ln y2)^2$	(-0.03)	0.02	-1.20
δ_{23}	$(\ln y2)(\ln y3)$	(0.00)	0.03	0.10
δ_{33}	$0.5(\ln y3)^2$	(0.13)**	0.06	2.06
η_{11}	$(\ln\frac{w1}{w3})(\ln y1)$	(0.04)	0.05	0.76
η_{12}	$(\ln\frac{w1}{w3})(\ln y2)$	(0.09)*	0.04	2.45
η_{13}	$(\ln\frac{w1}{w3})(\ln y3)$	(-0.20)*	0.05	-3.74
η_{21}	$(\ln\frac{w2}{w3})(\ln y1)$	(0.06)	0.05	1.16
η_{22}	$(\ln\frac{w2}{w3})(\ln y2)$	(-0.04)***	0.03	-1.33
η_{23}	$(\ln\frac{w2}{w3})(\ln y3)$	(0.19)*	0.05	4.07
ϖ_{11}	$0.5(\ln E)^2$	(0.24)*	0.05	4.82
φ_{11}	$(\ln\frac{w1}{w3})(\ln E)$	(0.31)*	0.09	3.43

(continued)

Table 6.3 The Maximum Likelihood Parameters Estimation for the Preferred Alternative Profit (continued)

Parameters	Variables	Coefficients	Standard error	t=ratio[1]
φ_{21}	$(\ln\frac{w2}{w3})(\ln E)$	(-0.52)*	0.12	-4.47
ζ_{11}	$(\ln y1)(\ln E)$	-0.07	0.05	-1.31
ζ_{21}	$(\ln y2)(\ln E)$	(-0.13)**	0.06	-2.25
ζ_{31}	$(\ln y3)(\ln E)$	(0.06)	0.10	0.57
τ_1	t (time trend)	(-0.14)*	0.01	-10.37
τ_{11}	$0.5(t)^2$	(0.03)*	0.00	14.18
κ_1	$\ln(y1)(t)$	(0.00)	0.01	0.43
κ_2	$\ln(y2)(t)$	(0.01)	0.01	0.91
κ_3	$\ln(y3)(t)$	(0.02)*	0.01	2.56
θ_1	$\ln(\frac{w1}{w3})(t)$	(-0.08)*	0.01	-11.79
θ_2	$\ln(\frac{w2}{w3})(t)$	(0.06)*	0.01	9.97
χ_1	lnc1 (asset quality)	(-0.27)*	0.04	-6.51
χ_{11}	$0.5(\ln c1)^2$	(0.00)	0.02	0.16
ρ_{11}	$\ln(\frac{w1}{w3})(\ln c1)$	(0.06)**	0.03	1.98
ρ_{21}	$\ln(\frac{w2}{w3})(\ln c1)$	(-0.02)	0.03	-0.59
ω_{11}	$\ln(y1)(\ln c1)$	(-0.01)	0.03	-0.27
ω_{21}	$\ln(y2)(\ln c1)$	(-0.03)**	0.02	-1.77
ω_{31}	$\ln(y3)(\ln c1)$	(-0.03)	0.03	-0.93
χ_2	lnc2 (capital adequacy)			
χ_{22}	$0.5(\ln c2)^2$			
ρ_{12}	$\ln(\frac{w1}{w3})(\ln c2)$			
ρ_{22}	$\ln(\frac{w2}{w3})(\ln c2)$			
ω_{12}	$\ln(y1)(\ln c2)$			
ω_{22}	$\ln(y2)(\ln c2)$			
ω_{32}	$\ln(y3)(\ln c2)$			
Ψ	constant	(-3.03)	0.72	-4.19

(continued)

Table 6.3 The Maximum Likelihood Parameters Estimation for the Preferred Alternative Profit (continued)

Parameters	Variables	Coefficients	Standard error	t=ratio[1]
Ψ_1	Ownership Structure (z1)	(-0.11)	0.16	-0.70
Ψ_{2b}	Islamic (z2b)	(-0.65)***	0.42	-1.56
Ψ_{2c}	Investment (z2c)	(-0.60)	0.63	-0.95
Ψ_3	Total assets (z3)	(1.13)*	0.12	9.14
Ψ_4	Age of bank (z4)	(0.01)**	0.01	2.16
Ψ_5	Corporate control (z5)	(-0.00)	0.16	-0.02
Ψ_{6a}	Market structure/ concentration (z6a)	(-0.45)	0.65	-0.68
Ψ_{6b}	Market structure/ market share (z6b)	(-0.53)***	0.38	-1.41
Ψ_7	Year 1997-2002 (z8)	(0.40)***	0.27	1.44
Ψ_8	Year 2003-2006 (z9)	(-0.97)**	0.45	(-2.18)
σ^2		(0.36)*	0.03	14.26
γ		(1.00)*	0.000	56225.5
log-likelihood	76.49			
LR	229.9			
No. of observations	281			
Degrees of freedom[2]	230			

[1]t-ratio defines the ratio of the estimated coefficients to the corresponding standard errors.
[2]Degrees of freedom equals number of observations in the sample minus the number of estimated coefficients in maximum likelihood model (i.e. 281-51=230).
*, **, *** significance of parameters of coefficients at 1%, 5% and 10% levels, using the t-distribution table and the t-ratios obtained at the given degrees of freedom (i.e. 230). The critical values of the t-ratios at significance levels of 1%, 5% and 10% are 2.326, 1.645 and 1.282, respectively.

6.3 Testing Research Hypotheses

Having (i) tested the coefficients of the three preferred SFA models and (ii) analysed the main properties of the three models, the seven hypotheses outlined in Chapter 4 can now be tested using the cost and two profit efficiency SFA models:

Hypothesis 1: Bank efficiency has improved since the implementing of deregulation in Jordanian banking system, 1993-2006[83].

Hypothesis 2: Foreign banks are more cost (profit) efficient than domestic banks.

Hypothesis 3: Specialised banks are less cost (profit) efficient.

Hypothesis 4: Bank size is positively related to cost (profit) efficiency.

Hypothesis 5: Well-established banks are more cost (profit) efficient than newly established banks

Hypothesis 6: CEO-Chairman affiliation is negatively related to banks' cost (profit) efficiency (i.e. chairman of bank board and CEO are the same person).

Hypothesis 7a: High concentration is negatively related to cost (profit) efficiency.

Hypothesis 7b: High market share is positively related to cost (profit) efficiency.

Additionally, as identified in Chapter 5, two further hypotheses stemming from selecting the preferred model, can be tested:

Hypothesis 8: Banks with a high percentage of non-performing loans are incurring more costs and achieving less profits.

Hypothesis 9: Banks with low levels of capital adequacy are incurring more costs and achieving less profits.

As previously mentioned (see Chapter 5) there are two kind of exogenous variable introduced in estimation of cost and profit frontier: control variables and environmental variables. Thus hypotheses 2-9 are tested by using the three SFA models using control and environmental variables. The control variables are assumed to have a direct influence on the cost and profit functions structure (i.e. the position of the frontier) and these variables interact fully with bank inputs and outputs. As shown in Chapter 5,

[83] Hypothesis 1 will be tested using both SFA and DEA in section 6.4 to give an indication of the extent to which the steps taken by the CBJ have affected positively or negatively the banks' efficiency scores level.

hypotheses 8 and 9 are relate to the control variables C1 (asset quality) and C2 (capital adequacy) and the appropriate testing procedure for hypotheses relating to control variables is to test simultaneously the significance of groups of coefficients, using the log ratio test (Coelli et al., 2005).

The environmental variables, included in all three models (i.e. cost, standard profit and alternative profit models) will be used to test hypothesis 2-7. As these variables were not interacted with input prices and outputs (see Battese and Coelli, 1995). These variables only impact on the measures of inefficiency (u_i) (Battese and Coelli, 1995). Therefore, hypothesis 2-7 will be tested by looking at the t-ratio for each coefficient for each of the environmental variable. Additionally, as u_i measures inefficiency, the significant and positive coefficients associated with the environmental variable(s) mean that inefficiency has increased, whilst the significant and negative coefficients mean that inefficiency has decreased.

In the following analysis it must be noted that for hypotheses 2-9, each hypothesis is being tested of:

(i) Cost efficiency (Table 6.1) and;
(ii) Profit efficiency (Tables 6.2 and 6.3).

6.3.1 Testing Hypotheses 2-7

As mentioned earlier each hypothesis has two parts: the first relates to the cost efficiency and the second part relates to profit efficiency. The simple way to test these hypotheses is by looking at the t-ratio for each coefficient associated with the environmental variables (i.e. Z1-Z7). In testing how these hypotheses relate to the cost efficiency, Table 6.1 is used, and for profit efficiency, Tables 6.2 and 6.3 are used.

Hypothesis 2 *(foreign banks are more cost (profit) efficient than domestic banks)* relating to the ownership structure (Z1). The coefficient of Z1 in Table 6.1 is negative -0.143 and significant at a level of 1%. This suggests that, for foreign banks, the inefficiency is less than that of domestic banks and this leads to the acceptance of the first part of hypothesis 2. This finding is consistent with the literature, as most studies in developing countries found that foreign banks were the most cost efficient (see Isik and Hassan, 2003). With regard to the second part of hypothesis 2, the coefficient of Z1 in

Table 6.2 and 6.3 is negative and insignificant for both standard and alternative profit models. This leads to the rejection of the second part of hypothesis 2 (foreign banks are more profit efficient than domestic banks). This indicates that there is no difference between foreign and domestic banks in terms of profit efficiency. A possible explanation is that the foreign banks are more concerned in controlling their costs than in generating profit. Moreover, foreign banks in Jordan apply strict criteria in granting loans and are not allowed to deal with stocks in the Amman Financial Market. These factors could have a negative impact on foreign banks' profit efficiency (later in this chapter cost and profit efficiency scores for domestic and foreign banks will be analysed in detail).

Hypothesis 3 (specialised banks are less cost (profit) efficient than their unspecialised counterparts) relating to specialisation (Z2). As mentioned in Chapter 5, there are three kinds of banks in Jordan: commercial, investment and Islamic banks, and to see the effects of specialisation on the level of cost and profit efficiency, we assign dummy variables for each group of banks (i.e. Z2a for commercial banks[84], Z2b for investment banks and Z2c for Islamic banks). Table 6.1 shows that the coefficient associated with Z2c (investment banks) is positive 0.318 and not significant whereas the coefficient associated with Islamic banks (Z2b) is positive 0.203 and significant at the 1%. This indicates that the Islamic banks are less cost efficient than commercial banks (Z2a) whereas there is no difference in cost efficiency of commercial and investment banks. This leads to an acceptance of the first part of hypothesis 3 (that specialised banks are less cost efficient than their unspecialised counterparts). This finding is consistent with Hassan (2005), who reported that Islamic banks are less efficient because they follow religious exigencies and avoid any transactions based on interest rates. Hassan (2005) also reported that Islamic banks operate in regulatory environments which are not supportive of their operation (this applies to Jordan, as there are no special regulations for Islamic banks). Moreover, the Islamic banks produce distinct services and different product mixes requiring a more intense use of inputs and more specialised personnel. With regard to profit efficiency Tables 6.2 and 6.3 show that the coefficient associated with Z2b (Islamic) is negative and significant for both standard profit and alternative

[84] Excluded from equation as base case for technical reason. Since the qualitative variable specialisation has three categories (commercial, investment, and Islamic banks) only two categories are used and one category is dropped from the equation to avoid the situation of perfect collinearity (see Gujarati, 2003). In our case we dropped the commercial banks dummy variable as base case.

profit and models (-1.44 and -1.56 respectively), whereas the coefficient associated with Z2c (investment) is negative and insignificant for both standard profit and alternative profit and models. This indicates that the Islamic banks are more profit efficient than commercial banks (Z2a) whereas there is no difference in profit efficiency of commercial and investment banks. This leads to rejection of the second part of hypothesis 3 (later in this chapter efficiency scores of commercial, investment and Islamic banks will be analysed in detail).

Hypothesis 4 (bank size is positively related to cost (profit) efficiency) relates to the size of bank (Z3) and the coefficient of Z3 in Table 6.1 is negative -0.134 and significant at a level of 1%: this indicates that large banks are more cost efficient than smaller banks. Thus, we accept the first part of hypothesis 4 that large banks are more cost efficient than their smaller counterparts. This can be attributed to the larger Jordanian banks' enjoying several advantages over smaller banks, such as their ability to use more efficient technology at less cost. With regard to profit efficiency Tables 6.2 and 6.3 show that the coefficient associated with Z3, for both standard and alternative profit models, is positive and significant at a level of 1% (1.0 and 1.13, respectively). This indicates that large banks are less profit efficient than smaller banks. Thus, we reject the second part of hypothesis 4 that large banks are more profit efficient than their smaller counterparts (later the efficiency scores regarding bank size will be analysed in detail).

Hypothesis 5 (well-established banks are more cost (profit) efficient than newly established banks) relates to the age of a bank (Z4). Table 6.1 shows that the coefficient associated with Z4 is positive 0.010 and highly significant. This suggests that new banks are more efficient than older banks, thus leading to rejection of the first part of hypothesis 5. With regard to profit efficiency Tables 6.2 and 6.3 show that the coefficient associated with Z5 in both standard and alternative profit models is positive and significant (0.03 and 0.01, respectively). As cost model we reject the hypothesis that old banks are more profit efficient than small banks. Possible explanation for this (as suggested by Isik and Hassan, 2003) is that old banks in developing countries suffer from bureaucracy, whilst new established banks employ the most efficient technology available.

Hypothesis 6 (CEO-Chairman affiliation is negatively related to banks' cost (profit) efficiency) relates to corporate control (Z5). Table 6.1 shows the coefficient associated with Z5 is positive 0.028 and not significant: this leads to the rejection of the first part of hypothesis. With regard to profit efficiency Tables 6.2 and 6.3 show that the coefficient of Z5 in the standard profit model is negative and significant and negative and insignificant in the alternative profit model. As in the cost model we reject the second part of hypothesis 6. The principal-agent problem is not common in Jordanian banks and this is possibly because most are owned and managed by families. This is consistent with Isik et al. (2004) who reported that the agency problem does not hold in the Jordanian banking industry because most of the banks in Jordan are closely held, where owners are strongly involved in management.

Hypothesis 7 relates to market structure (Z6a and Z6b). As mentioned in Chapter 5 there are two SCP hypotheses that can be tested in order to examine the relationship between the market structure and banks' efficiency: the traditional and the efficient hypotheses (for more detail see Chapters 3 and 5). Thus hypothesis 7 has two parts. The first part is tested for the traditional hypothesis (Z6a) (High concentration is negatively related to cost-and-profit efficiency) and the second part is for the efficient hypothesis (Z6b) (High market share is positively related to cost and profit efficiency). Table 6.1 shows that the coefficient associated with concentration (Z6a) is negative -0.015 but not significant, whereas the coefficient associated with market share (MS) is negative -0.07 and significant: this leads to the rejection of hypothesis 7a (that concentration (HI) is negatively related to cost efficiency), and the acceptance of hypothesis 7b (that market share is positively related to cost efficiency). With regard to profit efficiency, Tables 6.2 and 6.3 show that the coefficient associated with Z6a is negative for both standard and alternative profit models (significant for standard and insignificant for alternative). This leads to the rejection of hypothesis 7a relating to profit efficiency (High concentration is negatively related to profit efficiency). With regard to market share (Z6b), Tables 6.2 and 6.3 show that the coefficient associated with Z6b is negative and significant for both standard and alternative profit models. This leads to the acceptance of hypothesis 7b (that market share is positively related to profit efficiency). The main conclusion from hypothesis 7 implies that the efficient hypothesis of the SCP paradigm may be hold for Jordanian banks.

Finally, Table 6.4 summarises the testing of hypotheses 2-7.

Table 6.4 Testing Hypothesis 2-7

Hypothesis	Cost Efficiency	Standard Profit Efficiency	Alternative Profit Efficiency
Hypothesis 2 Foreign banks are more cost (profit) efficient than domestic banks.	Accept	Reject	Reject
Hypothesis 3 Specialised banks are less cost (profit) efficient.	Accept	Reject	Reject
Hypothesis 4 Bank size is positively related to cost (profit) efficiency.	Accept	Reject	Reject
Hypothesis 5 Well-established banks are more cost (profit) efficient than newly established banks.	Reject	Reject	Reject
Hypothesis 6 CEO-Chairman affiliation is negatively related to banks' cost (profit) efficiency.	Reject	Reject	Reject
Hypothesis 7a High concentration is negatively related to cost (profit) efficiency.	Reject	Reject	Reject
Hypothesis 7b High market share is positively related to cost (profit) efficiency.	Accept	Accept	Accept

6.3.2 Testing Hypotheses 8-9

As shown earlier, hypotheses 8 and 9 relate to control variables C1 (asset quality) and C2 (capital adequacy). The control variables assumed have a direct influence on the cost function structure and all these variables interact fully with bank inputs and outputs. As shown earlier, when variables interact a problem of multicollinearity may be appearing. A more appropriate testing procedure for hypotheses relating to control variables is to test simultaneously the significance of groups of coefficients, using the log ratio test (Coelli et al., 2005). According to the selection procedures mentioned in Chapter 5, the general model without capital adequacy is preferred for the cost model: this led to acceptance of hypothesis 8 that banks with a high percentage of non-performing loans are incurring more costs and rejection of hypothesis 9 states that banks with high capital adequacy ratio are incurring less costs. Given the limitations of using t-ratio tests in the case of interaction, the coefficient of asset quality (C1) (see Table 6.1) is significant and positive which suggests that banks with high levels of non-performing loans incur more costs than banks with low levels of non-performing loans.

With regard hypotheses 8 and 9 in profit models and according to the selection procedures mentioned in Chapter 5 (see Table 5.6), the general standard profit model with asset quality (C1) and capital adequacy (C2) is the preferred model. This led to acceptance of hypothesis 8 that banks with a high percentage of non-performing loans (C1) are incurring less profits and rejection the hypothesis 9 that banks with high capital adequacy ratio (C2) are incurring more profits. The coefficient of asset quality (C1) (see Table 6.2) is significant and negative (i.e. -0.13): this suggests that banks with high levels of non-performing loans achieve less profits than banks with low levels of non-performing loans. Although, the capital adequacy (C2) should be included in the preferred model according to selection criteria mentioned in Chapter 5 the coefficient of capital adequacy (C2) is negative but not significant. This means that the capital adequacy ratio does not have impact on the level of banks' profit.

With regard to alternative profit model and according to the selection criteria mentioned in Chapter 5 that the preferred model is the one without capital adequacy (C2) and with asset quality (C1). The coefficient of asset quality (C1) in the alternative profit model is negative (i.e. -0.27) and significant (see Table 6.3). This means that, on average, 1% increase in non-performing loans will decrease the profit by 0.27%.

6.4 Impact of Deregulation on the Level of Banks' Efficiency

The main research hypothesis regarding the impact of deregulation will be tested by analysing the trend of the estimated cost and profit efficiency scores for Jordanian banks over the period 1993-2006. This section will show the cost and profit efficiency scores obtained from SFA based on the preferred models and the trend of measured scores over the period 1993-2006. Moreover, the efficiency scores from DEA will be reported to see whether the efficiency scores from DEA give the same trend that obtained from SFA efficiency scores. The main research hypothesis above will be tested by comparing the change in efficiency scores using both SFA and DEA over the period 1993-2006.

6.4.1 Efficiency Scores from SFA

1. Cost Efficiency Scores

The cost efficiency scores for Jordanian banks over the period 1993-2006 are derived from the preferred cost model (see Table 6.1). The average cost efficiency for Jordanian banks over 1993-2006 is 83.1% although the efficiency scores varied over time from 85.6% in 1993 to 79.2% in 2006 (Table 6.5). These estimates suggest that the Jordanian banks can produce the same levels of output and reduce their cost by about 20%. The estimates of average cost efficiency for Jordanian banks is well within the range estimated for other countries, including the US and European studies. In general, the studies using stochastic methodologies have found inefficiency of the order of 15%-30% (see Berger and Humphrey, 1997; Goddard et al., 2001).

Figure 6.1 and Table 6.5 show the trend of efficiency scores over 1993-2006 and suggest that average cost efficiency has slightly but not significantly improved over the period 1993-1996. As mentioned earlier this period was characterised by the deregulation of the interest rate and Humphrey and Pulley (1997) stated that during deregulation of the interest rate, banks try to respond in three ways. First, cost offset and reduction is an attempt to offset higher deposits interest costs with higher explicit and implicit fees for small deposits[85]. The second response is to transfer some of the higher funding cost and interest rate risk to borrowers (i.e. floating rate of loans). The third response is to expand risky assets to obtain more revenue.

Jordanian banks responded by creating more floating rate loans. Accordingly, over the period 1993-1996 the interest rates on both deposits and loans increased, but the percentage increase in the interest rates on loans was more than that the increase in the interest rates on deposits (CBJ, 1998). These led to a decrease in funding costs and subsequently a decrease in the operating costs for Jordanian banks.

Despite the CBJ's efforts to put in place many important deregulation measures during 1997-2000 (see Table 4.3), the average efficiency scores decreased from 86%-80%. This can be attributed to the following factors facing Jordanian banks. First, during these years, as mentioned earlier (see Chapter 4), there was a decrease in customer deposits as a result of many Jordanians who worked in the Gulf having returned to Jordan following the Iraq invasion of Kuwait in 1990 and the first Gulf War in 1991 (Isik et al., 2004). More than 300,000 people returned and the remittance of these Jordanians was a main source of deposits in Jordanian banks (Tian and Zeitun, 2007). To compensate for the decrease in customer deposits, most banks used more expensive the inter-bank loans to finance their operations.

[85] In the case of Jordan, from 1995 most banks had started to impose specific fees on deposits of less than 100 JOD.

Second, over the years 1997-2000, as mentioned earlier (see Chapter 4) the main deregulation applied by the CBJ was concentrated on giving banks greater autonomy to produce a variety of products and services. Also, ceilings on credit extended by banks were eliminated. The prudential regulations in this period were inadequate, which in turn made Jordanian banks more vulnerable to different risks. This resulted in an increase in the percentage of non-performing loans, for example the percentage of non-performing loans increased from 20% in 1996 to an average of 35% between 1997-2000. The CBJ asked most Jordanian banks to make adequate provisions to face non-performing loans, which in turn increased banks' costs.

Through the years 2001 and 2002, the cost efficiency of Jordanian banks improved but decreased sharply in the year 2003 to low of about 77%. The main reason for this decrease was that the Jordanian banks faced many crises in 2002-2003 (see Chapter 4), which in turn negatively affected banks' cost efficiency.

After the year 2003, the cost efficiency began to improve as a result of many foreign banks' having come to operate in Jordan (due to change in regulations), which in turn motivated domestic banks to decrease their operating costs.

Finally, it should be noted that the variables Z7 and Z8 were introduced into the estimation of the SFA cost model to see the impact of the deregulation (in specific years) on the levels of cost efficiency. The coefficient associated with the years 1997-2002 (Table 6.1) was negative and insignificant which shows that the measures taken in these years did not improve cost efficiency within Jordanian banks. However, the coefficient for the years 2003-2006 (Table 6.1) was negative and significant, which suggests that the measures taken after the year 2003 improved the levels of cost efficiency within Jordanian banks.

Figure 6.1 Average Cost Efficiency Scores for Jordanian Banks 1993-2006

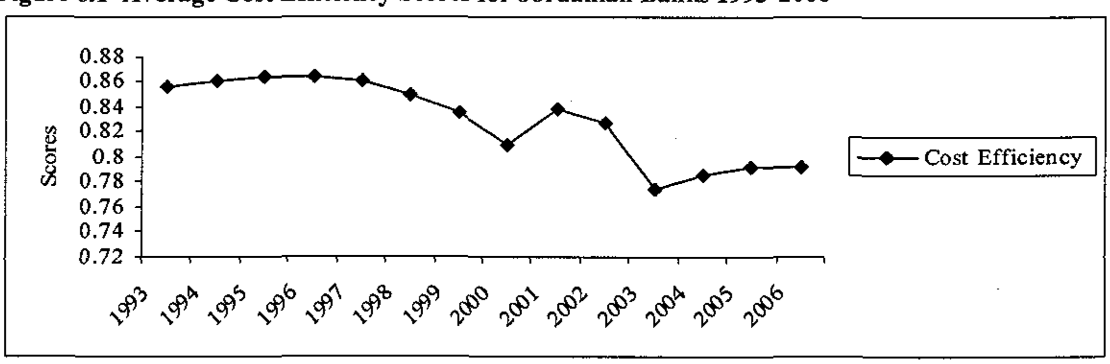


Table 6.5 Average Cost Efficiency Scores for Jordanian Banks 1993-2006

Years	No. of Banks	Mean	Std. Dev.	Min	Max
1993	20	0.86	0.08	0.74	0.99
1994	20	0.86	0.09	0.68	1.00
1995	20	0.86	0.08	0.74	0.99
1996	19	0.86	0.08	0.74	0.97
1997	18	0.86	0.08	0.72	0.99
1998	20	0.85	0.08	0.73	1.00
1999	20	0.84	0.10	0.68	1.00
2000	20	0.81	0.10	0.61	0.98
2001	20	0.84	0.09	0.66	0.99
2002	19	0.83	0.09	0.69	0.99
2003	19	0.77	0.10	0.62	0.99
2004	22	0.79	0.11	0.61	0.99
2005	22	0.79	0.10	0.67	0.99
2006	22	0.79	0.09	0.64	0.94
Average 1993-2006		0.83			

2. Standard and Alternative Profit Efficiency

The average means of the alternative and standard profit efficiency scores for Jordanian banks over the period 1993-2006 (see Table 6.6) are 80% and 84%, respectively. This suggests that the level of profit could be increased by between 16%-20%, with the same level of outputs. From a close look at Figure 6.2 and Table 6.6, we can note the scores obtained from both the alternative and the standard profit models vary over the period 1993-2006. With regard to the average alternative profit efficiency scores, the Jordanian banks' efficiency scores worsen from 83% in 1993 to 59% in 2006, while the standard profit efficiency model average score varied from 83% in 1993 to 85% in 2006. If we segment the average efficiency scores from the alternative and the standard profit models over the period 1993-2006 into two periods, 1993-2003 and 2004-2006, we can see that the trend of the alternative and the standard profit efficiency scores over the period 1993-2003 is the same, while the trend is different over the period 2004-2006. Throughout the period 1993-1997, both the alternative and the standard profit models show that the profit efficiency scores improved over this period. As mentioned earlier, this period was characterised by the deregulation of the interest rate and banks tried to respond to such deregulation in three ways (Humphrey and Pulley, 1997). With respect to Jordanian banks, they actually responded by (i) imposing extra fees on (some) deposits less than a specific amount and (ii) floating the interest rate on loans. The interest rate structure for deposits and loans for Jordanian banks over the period 1993-

1997 was increased, but the percentage increase in the loans interest rates was more than the increase in the interest rates on deposits (CBJ, 1998). For example, the interest rate margin in the banking industry in Jordan increased after the deregulation of interest rates from 5% to 6% (see Table 4.12). This means that banks during this period had some market power by setting prices less favourably for consumers (lower deposit rate, higher loan rates).

Figure 6.2 shows that the profit efficiency scores for both the alternative and the standard profit models worsened over the period 1997-2000. The average alternative profit efficiency scores declined from 84% to 74%, whereas the average standard profit efficiency scores declined from 86% to 82%. This period was characterised by the deregulation of banking products and services, i.e. removing some of the restrictions on the scope of banks' operations, (see Table 4.3 in Chapter 4). Throughout this period the product mix offered by Jordanian banks changed and the banks reacted by expanding their risky assets (i.e. investments) in order to reap higher revenue. For example, the growth in investments was on average 35% over the period 1997-2001, compared to average negative growth during 1993-1996 (see Table 4.7, Chapter 4). This unplanned growth subjected many Jordanian banks to higher risks and resulted in many of them facing large losses. Additionally during this time, the supervisory and regulatory framework in Jordan was arguably inadequate to keep up with banks' attitude to increasing the risk taken (Maghyereh, 2002).

As mentioned earlier, there were two departments responsible for banks' regulation and supervision and the level of coordination between these departments was very low. The non-performing loans for Jordanian banks increased from 20% in 1996 to an average of 35% between 1998-2000 (see Table 4.11, Chapter 4). Most banks were therefore asked by the CBJ to increase their non-performing loans provisions, which in turn negatively affected their levels of profit.

Over the years 2001 to 2004 the average alternative and standard profit efficiency scores increased slightly and followed the same trend (Figure 6.2 and Table 6.6). After 2004, the average alternative profit efficiency scores decreased dramatically from 85% in 2004 to only 58% in 2006, whereas the average scores for the standard profit efficiency decreased only slightly from 87% in 2004 to 84% in 2006. The different trend depicted by each model after 2004 (see Figure 6.2) could be explained with reference to:

(i) The underlying assumption of each model with respect to market power[86]. The alternative profit efficiency approach was built on the assumption that banks have some market power in determination of output prices, thus their prices are endogenous and the profit frontier is determined by the price on inputs and the outputs produced (see Berger and Mester, 1997). But the standard profit approach assumes that the market is competitive and no firm has an impact on the determining of the output price. Under standard profit frontier, the profit is the function of the output and input prices.

(ii) The changing level of competition/concentration in the Jordanian banking sector. Competition in the Jordanian market improved after the year 2001 and the concentration trend measured by the Herfindhal index declined from 24% in year 2001 to 13% in year 2006 as a result of the entry of new foreign banks to the Jordanian banking market. In addition, the price competition measured by the interest rate spread (i.e. the difference between the interest rates on loans and deposit interest rates) decreased from 7% in 2001 to 4% in 2006.

Therefore, after 2004 the efficiency scores provided by the standard profit efficiency model would seen to best reflect what has actually been happening in the Jordanian banking market and the effects of deregulation. This is further supported by looking at the profit ratios which show that most of the profit financial ratio indicators improved after the year 2004 (see Chapter 4).

Despite there being differences in the scores of the alternative profit and the standard profit efficiency models, in most cases both approaches placed the most and least efficient banks in the same rank order. Additionally, variables Z7 and Z8 (see Tables 6.2 and 6.3) were introduced in the models to see the impact of the deregulation (in specific years) on the levels of profit efficiency. The coefficient associated with the years 1997-

[86] The standard profit frontier assumes existence of perfect competition in input and output markets, so that firms are price takers. Given vectors of output prices (p) and of input prices (w), the banking firm tries to maximise profits by adjusting amounts of vectors of output quantity (y) and input quantity (x) (Maudos and Pastor, 2003). Whereas alternative profit frontier assumes that possibility of imperfect competition or market power in setting of prices existed, banking firms try to maximise profits by adjusting input quantities (x) and output prices (p) (Maudos and Pastor, 2003).

2002 was negative (-0.21) and insignificant (for the standard profit model) and positive (0.40) and significant (for the alternative profit model). This suggests that the measures taken in these years did not improve profit efficiency in Jordanian banks. However, the coefficient associated with the years 2003-2006 was negative and significant (for both the standard and the alternative profit models). This suggests that the measures taken after 2003 did improve the levels of profit efficiency in the banks (see Tables 6.2 and 6.3). Appendices 6.1-6.3 show the efficiency scores based on SFA for all three models for all Jordanian banks, 1993-2006.

To sum up, both profit models show that the efficiency scores improved slightly over the period 1993-1996, then worsened markedly over the period 1997-2001. After 2003 the efficiency scores from the standard profit model improved slightly, where the efficiency scores from the alternative profit worsened after 2003. It could be argued that the deregulation measure undertaken by the CBJ over the period 1993-1996 and 2003-2006 had a little positive impact on the level of banks' profit efficiency, whereas the measures undertaken during 1997-2002 have great negative impacts on the level on banks' efficiency.

Figure 6.2 Average Alternative and Standard Profit Efficiency Scores 1993-2006

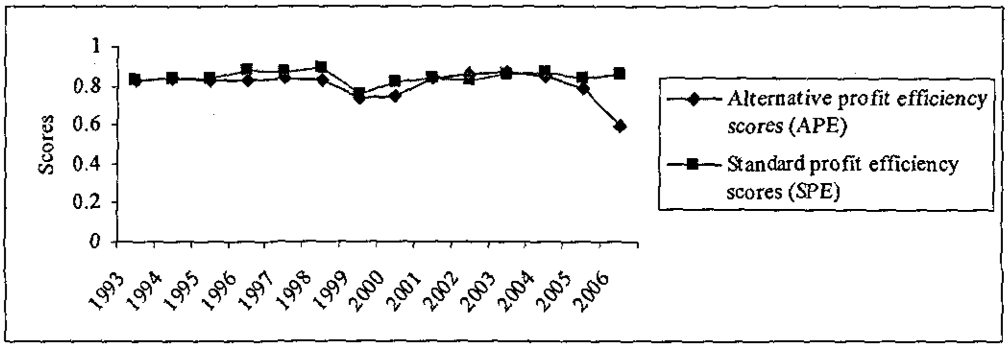


Table 6.6 Average Alternative and Standard Profit Efficiency Scores 1993-2006

Average Alternative Profit Efficiency Scores							Average Standard Profit Efficiency Scores					
Year	No. of banks	Mean	Std. Dev.	Min	Max		Year	No. of banks	Mean	Std. Dev	Min	Max
1993	20	0.82	0.10	0.65	0.95		1993	20	0.83	0.10	0.60	0.97
1994	20	0.84	0.09	0.66	0.94		1994	20	0.83	0.10	0.58	0.97
1995	20	0.83	0.07	0.66	0.94		1995	20	0.84	0.10	0.55	0.94
1996	19	0.83	0.07	0.68	0.94		1996	19	0.88	0.09	0.69	1.00
1997	18	0.84	0.7	0.65	0.94		1997	18	0.86	0.11	0.67	0.99
1998	20	0.82	0.10	0.58	0.93		1998	20	0.88	0.09	0.70	1.00
1999	20	0.73	0.20	0.03	0.96		1999	20	0.76	0.21	0.05	0.99
2000	20	0.74	0.19	0.22	0.94		2000	20	0.82	0.16	0.37	0.99
2001	20	0.83	0.14	0.49	0.96		2001	20	0.84	0.14	0.51	1.00
2002	19	0.86	0.15	0.44	0.96		2002	19	0.83	0.13	0.51	1.00
2003	19	0.87	0.13	0.47	0.97		2003	19	0.86	0.11	0.56	1.00
2004	22	0.85	0.13	0.43	0.97		2004	22	0.87	0.11	0.61	1.00
2005	22	0.78	0.15	0.48	0.96		2005	22	0.84	0.12	0.63	1.00
2006	22	0.59	0.15	0.38	0.85		2006	22	0.85	0.12	0.57	1.00
Average 1993-2006		0.80							0.84			

6.4.2 Efficiency Scores from DEA

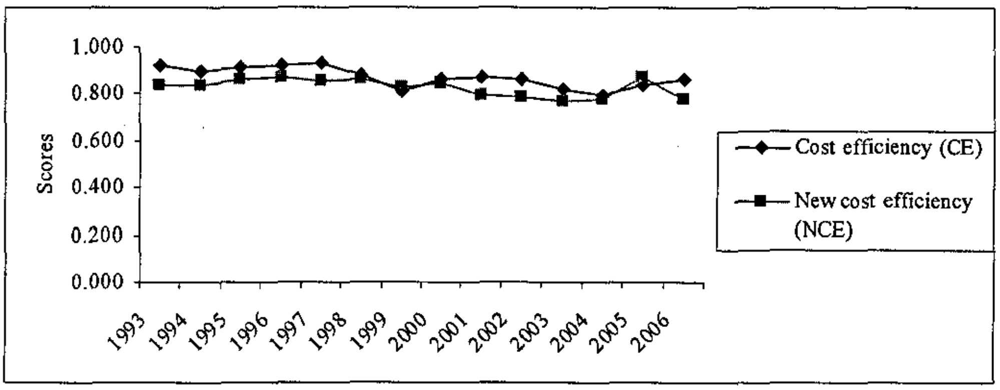
As mentioned earlier (see Chapter 2) there is no agreement between researchers whether the SFA or DEA can produce a better estimate of efficiency scores (Bauer et al., 1998). As outlined in Chapter 5, the DEA methodology is used to test the consistency of the efficiency estimates from the SFA. This section reports the efficiency measures obtained from DEA[87] in order to see whether the trend of the latter is similar to that of SFA. This could help in the validity if our conclusion from SFA regards the impact of deregulation on the efficiency levels of the Jordanian banks.

1. Cost and New Cost Efficiency

The average DEA efficiency scores for Jordanian banks 1993-2006 are 87% for cost efficiency (CE) and 83% for the new cost efficiency (NCE) measures, and these measures are close to the average efficiency scores obtained from SFA.

Figure 6.3 and Table 6.7 show the DEA cost efficiency scores for Jordanian banks between 1993-2006. The trend of the CE and NCE is very similar to those obtained from SFA. That is: the efficiency scores increased between 1993-1997; then decrease between 1998-2001. Then there is stability in the efficiency scores from 2002 to 2004. After the year 2004 the average efficiency scores based on CE is increased, where the average of the NCE is decreased.

Figure 6.3 Average DEA Cost Efficiency Scores for Jordanian Banks 1993-2006



[87] We follow Isik et al. (2004) and DeYoung and Hasan (1998) by constructing 14 separate annual efficiency frontiers, one for each year under study, to account for change in the regulatory conditions 1993-2006. However, the efficiency scores are also obtained by constructing single frontier for all banks over the period 1993-2006 and there are no significant differences in efficiency scores.

Table 6.7 Average DEA Cost Efficiency Scores for Jordanian Banks 1993-2006

Cost efficiency							New cost efficiency					
Year	No. of Banks	Mean	Std. Dev.	Min	Max		Year	No. of Banks	Mean	Std. Dev.	Min	Max
1993	20	0.92	0.10	0.66	1.00		1993	20	0.84	0.17	0.46	1.00
1994	20	0.89	0.12	0.54	1.00		1994	20	0.84	0.15	0.47	1.00
1995	20	0.92	0.10	0.67	1.00		1995	20	0.87	0.15	0.46	1.00
1996	19	0.92	0.09	0.75	1.00		1996	19	0.87	0.15	0.51	1.00
1997	18	0.93	0.08	0.76	1.00		1997	18	0.86	0.15	0.54	1.00
1998	20	0.88	0.12	0.65	1.00		1998	20	0.86	0.12	0.64	1.00
1999	20	0.81	0.14	0.55	1.00		1999	20	0.83	0.15	0.58	1.00
2000	20	0.86	0.11	0.61	1.00		2000	20	0.84	0.14	0.53	1.00
2001	20	0.87	0.10	0.7	1.00		2001	20	0.79	0.16	0.6	1.00
2002	19	0.86	0.11	0.68	1.00		2002	19	0.79	0.2	0.38	1.00
2003	19	0.82	0.13	0.64	1.00		2003	19	0.77	0.21	0.37	1.00
2004	22	0.80	0.19	0.42	1.00		2004	22	0.78	0.18	0.51	1.00
2005	22	0.84	0.16	0.6	1.00		2005	22	0.87	0.14	0.57	1.00
2006	22	0.87	0.12	0.64	1.00		2006	22	0.77	0.15	0.57	1.00
Average 1993-2006	0.87						Average 1993-2006	0.83				

2. Profit Efficiency

Figure 6.4 and Table 6.8 summarise the mean values of the Jordanian banks' profit scores over the year 1993-2006 based on the DEA profit efficiency (PE) and the DEA new profit efficiency (NPE). The PE measures average around 73% for the whole period, while the NPE score average around 75%. However, the scores mean for PE varied from 64% in 1993 to 80% in 2006, while the means of the NPE scores varied much less from 73% in 1993 to 76% in 2006. Appendices 6.4-6.6 show efficiency scores based on DEA for all Jordanian banks.

A close look at Figure 6.4 and Table 6.8 which show the trend of the DEA profit and the DEA new profit efficiency scores reveals that the general trend of the profit efficiency scores is almost similar to that of the SFA profit efficiency scores.

Figure 6.4 Average DEA Profit Efficiency Scores for Jordanian Banks 1993-2006

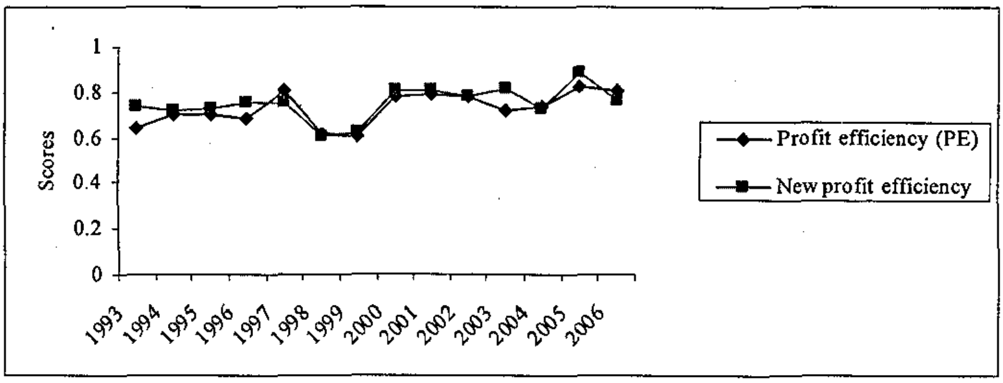


Table 6.8 Average DEA Profit Efficiency Scores for Jordanian Banks 1993-2006

Profit efficiency							New profit efficiency					
Year	No. of Banks	Mean	Std. Dev.	Min	Max		Year	No. of Banks	Mean	Std. Dev.	Min	Max
1993	20	0.64	0.27	0.01	1.00		1993	20	0.73	0.31	0.01	1.00
1994	20	0.70	0.31	0.04	1.00		1994	20	0.72	0.31	0.05	1.00
1995	20	0.70	0.31	0.04	1.00		1995	20	0.73	0.29	0.04	1.00
1996	19	0.69	0.25	0.29	1.00		1996	19	0.75	0.24	0.24	1.00
1997	18	0.80	0.22	0.31	1.00		1997	18	0.76	0.27	0.02	1.00
1998	20	0.62	0.32	0.13	1.00		1998	20	0.60	0.33	0.08	1.00
1999	20	0.61	0.28	0.03	1.00		1999	20	0.62	0.30	0.02	1.00
2000	20	0.78	0.17	0.46	1.00		2000	20	0.81	0.16	0.54	1.00
2001	20	0.79	0.20	0.43	1.00		2001	20	0.81	0.24	0.22	1.00
2002	19	0.78	0.29	0.11	1.00		2002	19	0.78	0.29	0.11	1.00
2003	19	0.72	0.31	0.04	1.00		2003	19	0.82	0.31	0.03	1.00
2004	22	0.74	0.26	0.3	1.00		2004	22	0.73	0.31	0.21	1.00
2005	22	0.83	0.23	0.28	1.00		2005	22	0.88	0.24	0.2	1.00
2006	22	0.80	0.21	0.43	1.00		2006	22	0.76	0.29	0.06	1.00
Average 1993-2006	0.73						Average 1993-2006	0.75				

To sum up, although both the SFA and the DEA are not producing identical efficiency scores for Jordanian banks, both of them show almost a similar trend over the entire study period 1993-2006. This could be reflecting what happened in the Jordanian banking market through the years 1993-2006. Noting the three aforementioned stages of deregulation The cost and profit efficiency scores for Jordanian banks improved after the deregulation of the interest rates (1993-1996) and then worsened through the period 1997-2002. As mentioned earlier, this period witnesses the deregulation of banks' products and services. The prudential regulations at this period within the CBJ were inadequate to cope with the attitude of banks towards expanding their operations in risky assets, which in turn led banks to become subject to more and/or different risks which in turn raised the percentage of non-performing loans. The percentage of non-performing loans for Jordanian banks rose from 20% in 1996 to an average of 35% over 1998-2000. During this period, most Jordanian banks were under-provisioned (CBJ, 2004) and most of their profits were directed to cover the shortage in provisions. These results are consistent with the views of Gruben and McComb (1997) and Merrick and Saunders (1985) who asserted that deregulation may be accompanied with consequences that may threaten the safety and soundness of the financial system, such as banks' being more likely to invest in risky products. Moreover, Jordanian banks were strongly influenced by unstable conditions facing Jordan during the period of the study (i.e. the first and second Gulf Wars).

However, after the year 2003, there was little improvement in the Jordanian bank's efficiency as a result of entry of many foreign banks into the Jordanian banking market. Moreover, the CBJ worked from the year 2001 to strengthen its regulation on corporate governance and the issues relating to risk management.

Referring to hypothesis 1 (see Chapter 4) it could be argued that the deregulation measures undertaken by the CBJ during 1993-1996 and 2003-2006 have positively affected the efficiency scores of Jordanian banks, where the measures put in place during 1997-2002 distorted the Jordanian banks' efficiency. For the entire period 1993-2006 the average efficiency scores are worsened.

Additionally, the results from both the SFA and DEA indicate that the profit inefficiencies[88] appear to be greater than the cost inefficiencies. Banks therefore need to focus more on revenue generation coupled with appropriate risk management practices and more prudential supervision from the CBJ regarding risky assets. Given that the CBJ was put in place to implement the Basel II Accord from the beginning of the year

[88] These results are consistent with many studies showing cost efficiency more than profit efficiency. For example, Berger and Mester (1997) found the profit efficiency in the US banking market is approximately half the cost efficiency; Rogers (1998) obtains average efficiency in profit of 69.2% as against 75.6% in costs, efficiency in revenue being lower (43.7%). In the case of EU banking system, Maudos et al. (2002) obtain average efficiency in profit of 84% as against 91% in costs. Maudos and Pastor (2003) stated that profit inefficiency is quantitatively more important than cost inefficiency, indicative of significant inefficiencies on the revenue side, either due to the choice of not the most suitable composition of production, given the prices of outputs, or due to bad pricing policy.

2008, this implementation could improve and enhance the risk management practice within Jordanian banks and improve their cost and profit efficiency.

6.5 Robustness of Efficiency Measures from SFA and DEA

In the light of the Bauer et al. (1998) recommendation, the robustness of the cost and the profit efficiency scores from SFA and DEA are tested using five consistency checks. That is with respect to: estimated efficiency scores from SFA and DEA should be consistent regarding comparable means; ranking of the banks; identification of the best and worst banks; stability over time and relation to non-frontier measures of performance (i.e. financial ratios) (Fiorentino et al., 2006). However, it should be noted that the scores obtained from SFA accounted for the differences between banks by including control and environmental variables, whereas that is not the case for DEA scores

6.5.1 Comparable Means

Table 6.9 reports a number of distributional characteristics of the cost and profit efficiency scores generated by SFA and DEA. The table shows that the means of the SFA cost efficiency scores and of the DEA are close. The standard deviation of DEA scores is more than that of SFA. This already suggests that failure to control for systematic difference (i.e. random error) yields fundamentally different scores between the two methods. In terms of skewness (denotes that observations are not spread symmetrically around a mean value), the DEA scores give more negative skewness since the DEA is more sensitive to measurement errors and outliers (Coelli et al., 2005). One common issue with DEA analysis is that the results can be very sensitive to outliers and measurement error since there is no random error embedded in calculation of DEA scores (Wanger et al., 2003). With regard to profit efficiency scores, Table 6.9 shows that the mean efficiency scores from the two SFA models (i.e. standard profit and alternative profit) averaged about 0.82, while the mean efficiency scores averaged about 0.74 across the two DEA models. The average of standard deviation from the DEA models was twice that of SFA models. This suggests again that the DEA scores are more sensitive to the outliers because they do not take into account the random error. In general both of SFA and DEA produce comparable means.

Table 6.9 Descriptive Statistics of Efficiency Scores by DEA and SFA

	Mean	S.D	Max	Min	Skewness
Cost efficiency SFA	0.83	0.09	0.99	0.60	-0.03
Cost efficiency DEA	0.87	0.13	1.00	0.42	- 0.70
New cost efficiency DEA	0.83	0.16	1.00	0.37	- 0.51
Alternative profit efficiency SFA	0.80	0.14	0.97	0.03	-1.60
Standard profit efficiency SFA	0.84	0.13	0.99	0.05	-1.50
Profit efficiency DEA.	0.73	0.26	1.00	0.01	- 0.60
New profit efficiency DEA	0.75	0.28	1.00	0.01	- 0.70

6.5.2 The Ranking of Banks

The second consistency test is the ranking order of banks based on the efficiency scores from both SFA and DEA. Bauer et al. (1998) argued that if the different models do not rank banks similarly, then policy authorities may not be able to identify which model provides a better measure of efficiency scores for banks and therefore can not draw proper conclusions based on the estimated efficiency scores. Table 6.10 contains Spearman rank-order correlation coefficients[89] showing how close the rankings of banks are among each of the DEA and SFA models. The rank-order correlations are positive, high and significant at the 5% level and are on average higher for DEA models. For example, the rank correlation between DEA cost efficiency (CE) and DEA new cost efficiency (NCE) is about 0.65, which in turn suggests that in most cases the DEA CE and the DEA NCE rank banks in the same order. The rank-order correlation between DEA CE and SFA CE is about 0.52, while the rank order correlation between DEA NCE and SFA CE is about 0.63. This suggests that both DEA and SFA place the banks in almost the same ranking. With regard to profit efficiency, the DEA models have high rank order correlation coefficients (i.e. 0.63 between DEA PE and DEA NPE). Despite the rank-correlations between DEA profit efficiently and SFA efficiency scores not being high (i.e. 0.19 between DEA PE and SFA PE), they do still rank some banks in the same order.

Having compared the rank order correlation between DEA and SFA models in terms of cost scores, such comparisons can be make between cost efficiency and profit efficiency scores to see whether cost efficient banks are also profit efficient. The bank ranking

[89] Statistic provides a measure of the association between two or more variables in terms of the rank order. It should be noted that this statistic does not measure the linear association between variables (Anderson et al., 1987).

under the profit efficiency approach differs from the respective cost efficiency ranking (i.e. low rank order correlation between cost efficiency and profit efficiency scores). For example the rank order correlation coefficient between DEA CE and SFA APE is low (i.e. 0.14). This suggests that it is not necessary for the bank to be profit efficient if it is to be cost efficient. Delis et al. (2009) found that most cost efficient banks in Greece are not the most profit efficient. Berger and Mester (1997) showed that profit efficiency may not be positively correlated with cost efficiency, suggesting that the measure of profit efficiency may include output features reflecting higher quality or greater market power in pricing. The difference in bank order under profit efficiency and cost efficiency could relate to the attitudes of management towards optimisation objectives and risks. Some banks may be concerned with controlling costs and others with revenue generation. Finally, it worth noting that despite the DEA and SFA methodologies' being based on different assumptions, they can rank some banks similarly.

Table 6.10 Spearman Rank-Order Correlation between DEA and SFA Scores

	DEA CE	DEA NCE	SFA CE	DEA PE	DEA NPE	SFA APE	SFA SPE
DEA CE	1.00						
DEA NCE	0.65*	1.00					
SFA CE	0.52*	0.43*	1.00				
DEA PE	0.63*	0.53*	0.35*	1.00			
DEA NPE	0.43*	0.43*	0.33*	0.63*	1.00		
SFA APE	0.14*	0.26*	0.07	0.19*	0.31*	1.00	
SFA SPE	0.21*	0.13*	0.24*	0.19*	0.21*	0.37*	1.00

* Correlation coefficient statistically significantly different from zero at the 5% level.

6.5.3 Best and Worst Performing Banks

Even if the different models do not always rank the banks similarly, they may still be useful for regulatory purposes if they are consistent in identifying the best and worst performing banks. To define these, we follow the Spong et al. (1995) and Bauer et al. (1998) method by ranking banks from the best efficient to the worst and then dividing the observations into four quartiles. The first quartile will represent the best efficient banks and the fourth quartile the worst efficient banks.

Table 6.11 shows the correspondence of the best and the worst performing banks using the cost efficiency scores and Table 6.12 shows the best and the worst performing using the profit efficiency scores. The upper triangle of the matrix in Tables 6.11 and 6.12

reports for each pair of frontier efficiency techniques the proportion of banks identified by one model as having efficiency scores in the top 25% also identified by the other model. Each number in the upper triangle of Tables 6.11 and 6.12 is the proportion of banks identified by one model as having efficiency scores in the best efficient 25% of banks also identified in the best efficient 25% by the other model. For example, of the banks identified in the top 25% by DEA CE, 34% were also identified as being in the top 25% by SFA CE. In general, there is good consistency among the DEA models and between the DEA and the SFA models. Within the DEA models, the correspondence of the best practice 25% of banks in cost efficiency is about 64% and for profit efficiency about 59%. The correspondence of the best and worst practice between DEA models and SFA models is accepted. For the cost efficiency, the correspondence of the best practice 25% of banks was 34% between DEA CE and SFA CE, while the correspondence of the worst practice 25% of banks was 59% between DEA CE and SFA CE.

Table 6.11 Best and Worst Performing Banks Based on Cost Efficiency

	DEA CE	DEA NCE	SFA CE
DEA CE		0.64	0.34
DEA NCE	0.58		0.37
SFA CE	0.59	0.45	

Notes:
1. Upper right triangle denotes top 25% performers.
2. Lower left triangle denotes bottom 25% performers.
3. DEA CE refers to DEA cost efficiency, DEA NCE to DEA new cost efficiency, SFA CE to SFA cost efficiency.

Table 6.12 Best and Worst Performing Banks Based on Profit Efficiency

	DEA PE	DEA NPE	SFA APE	SFA SPE
DEA PE		0.59	0.33	0.44
DEA NPE	0.67		0.52	0.41
SFA APE	0.42	0.50		0.45
SFA SPE	0.32	0.32	0.52	

Notes:
1. Upper right triangle denotes top 25% performers.
2. Lower left triangle denotes bottom 25% performers.
3. DEA PE refers to DEA profit efficiency, DEA NPE to DEA new profit efficiency, SFA APE to SFA alternative profit efficiency, SFA SPE to SFA standard profit efficiency.

6.5.4 Stability over Time

Bauer et al. (1998) argued that it is important for regulatory policy that the measures of efficiency scores should demonstrate a reasonable stability over time and not vary markedly from one year to the next. It is unlikely that a very efficient bank in one year would become very inefficient in the next[90]. Table 6.13 shows the year-to-year stability of DEA and SFA efficiency scores over time (1993-2006).

The numbers in each column are the rank order correlations between each pair of successive years. Thus, each number in column 1 depicts Spearman rank order correlations between years 1993 and 1994 and in column 2 between years 1994 and 1995, and so on for all columns.

Table 6.13 Stability of Efficiency Scores 1993-2006 by Paired Successive Years

	1*	2	3	4	5	6	7	8	9	10	11	12	13
SFA CE	0.69	0.71	0.85	0.92	0.69	0.75	0.83	0.84	0.81	0.92	0.94	0.85	0.76
SFA SPE	0.58	0.73	0.76	**0.40**	**0.10**	**0.10**	0.68	0.45	**0.39**	**0.34**	0.50	**-0.12**	**-0.05**
SFA APE	0.72	0.50	0.46	**0.44**	0.65	0.55	0.64	0.47	**0.31**	**0.06**	0.52	**0.35**	0.64
DEA CE	0.76	0.77	0.76	0.87	**0.40**	0.58	0.89	0.63	0.89	0.93	0.86	0.81	0.86
DEA NCE	0.85	0.86	0.87	0.82	0.66	0.91	0.76	0.65	0.69	0.83	0.78	0.51	0.63
DEA PE	0.73	0.81	0.71	0.81	**0.40**	0.68	0.78	0.71	0.59	0.8	0.69	0.78	0.86
DEA NPE	0.70	0.64	0.55	0.81	0.72	0.65	0.49	0.82	**0.40**	0.85	**0.44**	**0.44**	0.69

Correlation coefficients statistically significantly different from zero at the 5% level except numbers in bold

* 1= 1993-1994, 2 = 1994-1995, 3 = 1995-1996, 4 = 1996-1997, 5 = 1997-1998, 6 = 1998-1999, 7 = 1999-2000, 8 = 2000-2001, 9 = 2001-2002, 10 = 2002-2003, 11 = 2003-2004, 12 = 2004-2005, 13 = 2005-2006.

SFA CE refers to SFA cost efficiency, SFA SPE to SFA standard profit efficiency, SFA APE to SFA alternative profit efficiency, DEA CE to DEA cost efficiency, DEA NCE to DEA new cost efficiency,. DEA PE refers to DEA profit efficiency, DEA NPE to DEA new profit efficiency.

From Table 6.13 we can note the following. First, the efficiency ranking order for SFA CE, DEA CE, and DEA NE is more stable over time, but all models show a slight change. For example for SFA CE most of the banks efficiency scores remain stable over the period 1993-2006. That is the efficient banks continue to be efficient over the year 1993-2006. Since market conditions and competition have changed over 1993-2006 in the Jordanian banking market, relative changes of efficiency rankings over time are

[90] Based on the assumption that all banks are working in a stable market, but in some cases and as result of external or internal shocks, some banks may be efficient in one year will change dramatically to inefficient in the next year. In Jordan, many internal and external shocks happened during the study period (see Chapter 4).

reasonable. Second, the period of study is long (i.e. 14 years) and in the long term may reflect different degrees of technical change (Fiorentino et al., 2006) across the various banking groups. Some banks may be more successful in adopting new technologies than others, which in turn could improve their level of cost efficiency over time. In addition, between 1993-2006 many banks were subjected to re-structuring such as merging with other banks or re-structuring of their operations. These changes could have an impact on these banks in their efficiency scores becoming worse or improving over time (e.g. one Jordanian bank (National Bank) was an efficient bank between 1993-1997, and then changed markedly to an inefficient bank after 1997 as a result of its merger with another bank).

Third, the rank order for SFA profit efficiency (i.e. APE and SPE) shows some stability between 1993-1997 but post 1998 the order becomes unstable and inconsistent. This supports our previous findings that as a result of the deregulation measures taken after 1997, the Jordanian banks became more subject to high risks (i.e. credit risks), which in turn reduced the banks' profit efficiency. However, the scores for DEA profit efficiency show a more consistent ranking than those for SFA profit efficiency which can be interpreted in the light of DEA scores' not accounting for the differences between banks in terms of risk and quality of outputs (Coelli et al., 2005).

To sum up, rank order between DEA and SFA cost efficiency scores over time is fairly high and statistically significant, while the rank order for profit efficiency scores, especially SFA, is unstable and non-consistent. This could reflect that the deregulation measures taken over the period 1996-2002 have negative impacts on the efficiency of some banks.

6.5.5 Consistency with Performance Indicators Based on Financial Ratios

The last consistency test is to compare efficiency scores from DEA and SFA with financial ratio performance indicators. These indicators are commonly used by regulators and are based on accounting information rather than on microeconomic theory (Fiorentino et al., 2006). The most commonly used ratios for measuring bank performance are: ROA (return on average assets); ROE (return on average equities); CIR[91] (cost income ratio); S/A[92] (staff expenses over total assets) and TC/TR[93] (total

[91] Smaller CIR indicates greater cost saving.

costs to total revenue) (for more details on these measures see Chapter 4). These financial performance ratios are usually used by both managers and consultants to generally assess their performance and rank themselves against their peers within an industry (Bauer et al., 1998). Berger and Humphrey (1991) stated that a perfect correlation is not expected between frontier and financial ratios measures as the latter are based on accounting ratios and do not consider input prices and the output mix. Table 6.14 shows the correlations between cost efficiency scores generated by DEA and SFA and the *financial ratios performance measures.*

The results in Table 6.14 suggest that neither DEA nor SFA efficiency measures are highly correlated with the financial ratios performance measures. The low correlation between frontier scores and the financial ratios performance measures is in line with those reported by Bauer et al. (1998), Koetter (2006) and Fiorentino et al. (2006) and confirm that frontier measures contain additional information (i.e. prices and product mixes) compared to the financial performance measures. Table 6.14 indicates that the consistency between the frontier cost efficiencies and the financial cost-related measures (i.e. CIR, S/A and TC/TR) is substantially higher compared to the relationship with the financial profit measures (i.e. ROA and ROE). However, the DEA efficiency scores are generally more consistent with the financial performance measures than SFA efficiency scores. For example, the correlation between CIR and DEA CE is negative (-0.30) and this indicates that as long as the CIR decreases cost efficiency increases.

Table 6.14 Cost Efficiency Scores Correlations with Financial Ratio Performance Measures

	DEA CE	DEA NCE	SFA CE
Cost income ratio (CIR)	-0.30*	-0.28*	-0.189*
ROA	0.18*	0.17*	0.11
ROE	0.18*	0.17*	0.26*
S/A (operating expenses).	-0.41*	-0.45*	-0.20*
TC/TR	*-0.19**	*-0.22**	*-0.10*

*Correlation coefficient statistically significantly different from zero at the 5% level
Notes. ROA: return on average assets, ROE: return on average equities, CIR: cost income ratio, S/A: staff expenses over total assets and TC/TR: total costs to total revenue.

In the case of the profit indicators, (Table 6.15), the expected positive sign between the efficiency scores and the profitability financial ratio indicators (ROA and ROE) is always obtained. Thus, the most profit-efficient banking firms are also the most

[92] Smaller S/A indicates greater cost saving.
[93] *Smaller TC/TR indicates greater cost saving.*

profitable. It is important to emphasise that the correlations are higher with the DEA profit efficiency scores and the financial profit indicators. As in cost efficiency measures, the correlations between frontier efficiency measures and financial performance measures are not high. However, the DEA PE and DEA NPE are more correlated with non-frontier measures.

Table 6.15 Profit Efficiency Scores Correlations with Financial Ratio Performance Indicators

	DEA PE	DEA NPE	SFA APE	SFA SPE
Cost income ratio (CIR)	-0.35*	-0.53*	-0.22*	-0.22*
ROA	0.21*	0.48*	0.18*	0.22*
ROE	0.13*	0.40*	0.22*	0.27*
S/A (operating expenses).	-0.42*	-0.43*	-0.31*	-0.13*
TC/TR	-0.28*	-0.48*	-0.24*	-0.20*

*Correlation coefficient statistically significantly different from zero at the 5% level
Notes. ROA: return on average assets, ROE: return on average equities, CIR: cost income ratio, S/A: staff expenses over total assets and TC/TR: total costs to total revenue.

Despite the low level of correlation between the frontier measures and financial ratios performance measures, all measures are consistent in terms of direction. For example, a low level of financial cost-related measures is accompanied with a high level of frontier cost efficiency scores. This could justify that using of financial ratios as a measure of performance by the regulators is still valid to some extent.

To sum up, apart from the relation of frontier measures and the financial ratios performance measures there is a reasonable consistency between the efficiency scores generated from the two methodologies (i.e. DEA and SFA) using consistency checks (i.e. comparable mean, ranking, identification of the best and worst banks and stability over time) as both methodologies: generated almost comparable means; placed the banks in the same rank order; identified the best and worst performing banks; and provided consistent ranking over time. Thus, this could validate our conclusion regarding the impact of deregulation (i.e. testing hypothesis 1) on the efficiency of Jordanian banks using SFA and DEA.

6.6 Main Characteristics of Most and Least Efficient Banks

For regulatory policy, it is important to determine the main characteristics of the most and the least efficient banks in relation to the rating systems used by supervisory authorities, such as CAMEL. Moreover, the ownership structure, specialisation and bank size could be related to most and least efficient banks. This section will analyse cost and profit efficiency measures of the most and the least efficient banks in relation to the CAMEL rating system, ownership structure, specialisation and bank size.

6.6.1 CAMEL Rating System

CAMEL is a rating system followed by most of the supervisory authorities around the world. The rating is based on five factors represented by the acronym CAMEL, where C denotes capital adequacy, A asset quality, M management, E earnings and L liquidity. Bank supervisory authorities rate each bank on a scale of 1 (strong) to 5 (unsatisfactory) for each factor and the composite CAMEL rating also ranges from 1(basically sound in every respect) to 5 (extremely highly unsatisfactory or near-term probability of failure) (DeYoung, 1998). The assigned scores are used by supervisory authorities to decide the level of supervision they should assign to each bank and to identify banks in need of attention. The assigned ratings on each factor (i.e. capital, asset quality, management, liquidity and earning) are the result of both off-site monitoring, which uses monthly financial statement information to get specific ratios, and an on-site examination, from which bank supervisors gather further qualitative data about the compliance of bank management with the regulations and the existence of the proper corporate governance and written policies and procedures within a bank. Despite the regulatory authority's using some financial ratios to quantify the CAMEL rating, researchers have identified neither a precise financial variable corresponding to each CAMEL component nor a unique set of variables for the overall CAMEL rating (Gasbarro et al., 2002). The following are the indicators most commonly used by the CBJ to give scores for each CAMEL component.

Capital adequacy: Capital to risk weighted asset ratio according to the Basel I Accord, (1988) is the most popular ratio used as a measure of the quality of capital adequacy. Banks with a high capital adequacy ratio usually get a high CAMEL rating.

Asset quality: One of the most commonly used indicators for asset quality is non-performing loans to total loans (Ansari, 2006). Banks with higher levels of non-performing assets will result in lower asset quality ratings and a correspondingly lower CAMEL rating (Gasbarro et al., 2002).

Management: In the CAMEL rating system, management quality is treated as the most qualitative aspect and is subjectively assigned by supervisors based on their judgement of bank management systems, compliance and prudential practices (Gasbarro et al., 2002). However, there are some financial indicators used to evaluate a bank's management such as cost-income-ratio (CIR) and operating expenses per employee (i.e. salaries divided by the number of employees) (Ansari, 2006). Banks with a high percentage of these ratios usually receive a low CAMEL rating.

Liquidity: The most common indicators used are the liquid assets to total assets and deposit mix (customers' deposits to total deposits). The former measures the volume of liquid assets the bank keeps in its balance sheet and the latter measures the dependency of the bank on inter-bank loans. The dependency of banks on purchased funds is an indicator for the regulatory authority that banks may be facing a liquidity problem[94]. A high level of liquid assets and less dependency on purchased funds result in high liquidity quality and a correspondingly higher CAMEL rating.

Earning: The most commonly-used ratios for measuring banks' performance are ROA and ROE and earning assets[95] (Tian and Zeitun, 2007). Banks with high ratios relating to ROA and ROE usually receive a high rating.

To define the least and most efficient banks and relate that to the CAMEL rating system, this research follow the Spong et al. (1995) method by ranking banks from the most efficient to the least, and then dividing them into four quartiles. The first quartile will represent the most efficient banks and the fourth quartile will represent the least efficient. This approach enables one to analyse the difference between the most and the least efficient banks and to identify the properties determining bank efficiency in Jordanian banks. Table 6.16 reports some CAMEL indicators of the most and the least efficient banks. As Table 6.16 suggests, there is a consistency between most of the CAMEL indicators and the cost and the profit efficiency scores. On average, cost efficiency for the most efficient banks was 0.95, while for the least efficient it was 0.70. In profit efficiency, the most efficient banks have an average efficiency score of 0.93,

[94] Banks relying on purchased funds pay high interest rates compared with the interest rate paid to depositors. Continuous reliance on purchased funds could be seen as an inability of the banks to attract cheap customers' deposits.

[95] Earning assets represent all assets that can generate income such as loans and investments.

while the least efficient have an average of only 0.58. Table 6.16 suggests that the most efficient and the least efficient banks have the same level of capital adequacy ratio. This is consistent with our results in the specification of the preferred cost and profit model (Tables 6.1, 6.2 and 6.3) because the capital adequacy ratio did not make a significance difference and was not included in the preferred model. This is also consistent with Gasbarro et al. (2002) who found an insignificant relationship between capital adequacy ratio and CAMEL rating. With regard to asset quality, Table 6.16 confirms that the most efficient banks have a lower level of non-performing loans, while the least efficient banks have a higher level. Thus, the CAMEL indicator regarding asset quality is consistent with measured efficiency scores. This is consistent with our results in the specification of the preferred cost and profit models that suggest the asset quality has an impact on the specification of banks' cost and profit frontiers.

Management has a vital role in controlling bank costs and generating profit. The CIR, defined as non-interest expenses divided by the sum of net interest and non-interest income, is used as a measure of the ability of management to control operating costs (Forster and Shafer, 2005). Table 6.16 suggests that the most cost/profit efficient banks have a lower ratio of CIR and lower operating expenses compared to those for less efficient banks. With regard to earning, the table shows a consistency between the efficiency scores and the CAMEL indicators. The most efficient banks have higher earning ratios than the least efficient. Maintaining sufficient liquidity is necessary to meet banks' obligations and the table suggests that the most cost efficient banks are more liquid than the least cost efficient bank. Also, it suggests that the most efficient banks are less dependent on purchased funds than the least efficient banks. Finally, the above analysis could have a good implication for the CBJ by adopting efficiency scores for Jordanian banks as a tool that supports the CBJ decision scores derived from the CAMEL rating system[96].

[96] To ensure there are differences between the most and the least efficient banks in terms of the CAMEL indicators a t-test is made and refers to there being no difference between the most and the least efficient banks in terms of the capital adequacy ratio, ROA and earning assets, whereas there are differences between the most efficient and the least efficient banks in term of non-performing loans, operating expenses per employee, ROE, cost-income ratio and liquidity measures.

Table 6.16 CAMEL Indicators for Most and Least Efficient Banks

CAMEL Indicators	Cost Efficiency		Profit Efficiency	
	Most Efficient	Least Efficient	Most Efficient	Least Efficient
Capital Adequacy				
Capital to risk weighted assets[1].	0.09	0.10	0.10	0.097
Asset quality				
Non-performing loans to total loans	0.08	0.15	0.11	0.14
Management				
Cost-Income-Ratio (CIR)[2]	0.76	0.80	0.63	0.96
Operating expenses per employee[3]	0.01	0.03	0.02	0.02
Earning				
ROA[4]	0.01	0.01	0.02	0.01
ROE[5]	0.16	0.05	0.16	0.03
Earning assets[6]	0.86	0.85	0.86	0.85
Liquidity				
Cash and deposits at banks to total assets	0.52	0.39	0.45	0.45
Deposit Mix[7]	0.91	0.85	0.86	0.84

Notes:
[1]Equity to risk weighted assets.
[2]Non-interest expenses[97]/ (non-interest income + net interest income[98])
[3]Employees' expenses to number of employees.
[4]Net profit to average assets.
[5]Net profit to average equity.
[6]Performing loans plus investments plus deposits with banks bearing interest to total assets.
[7]Customers' deposits to total deposits.

6.6.2 Ownership Structure

As mentioned in Chapter 4, there are two types of banks in Jordan according to ownership structure: foreign and domestic. The analysing of the banks' efficiency scores according to this structure could give the regulatory authority useful information about best and worst management practice with respect to the foreign and local ownership (Spong et al., 1995). As reported earlier (see Table 6.1), the ownership structure has an impact on the inefficiency of banks (i.e. the dummy variable assigned for foreign banks is negative and significant, which means that foreign banks are less inefficient than domestic banks). Figure 6.5 and Table 6.17 show that over the years 1993-2006, foreign banks are more cost efficient than local banks. The average cost efficiency score for foreign banks is 0.88, while the average cost efficiency score for domestic banks is 0.80.

[97] Non-interest expenses include salaries, technology, buildings, supplies and administrative expenses.
[98] Net interest income equals interest income less interest expenses.

These results are consistent with studies in developing countries[99] that find foreign banks are more cost efficient than domestic banks (e.g. Bhattacharyya et al. 1997, Hao et al. 2001, Hasan and Marton, 2003, Isik and Hassan , 2002 and 2003, Harvylchyk, 2006, Kraft et al. 2006). The superior cost efficiency of foreign banks can be attributed to *inter alia* their better technology, management structure and home government support (Isik and Hassan, 2003).

The theory of comparative advantage, as discussed in detail in Mahajan et al. (1996), advocates that foreign banks may possess relative comparative advantages stemming from different operating strategies, differences in organisation structures and support from home management. Levine (1996) and Goldberg (2003) argued that foreign banks coming in from more industrialised countries with well established technologies may help foreign banks to operate more efficiently than domestic banks. Stiglitz (1994) argues that foreign banks are less sensitive to the government pressures to finance specific projects that may not be profitable, whereas domestic banks are more sensitive to such government pressure. For example, the domestic banks in Jordan are subjected to some kind of intervention from the government to channel investment funds to selected sectors (e.g. tourism, military housing finance at low interest rates). Moreover, the culture in Jordan is one heavily reliant on ties and relationships (i.e. services are obtained quickly according to the degree of influence one has among staff). For example, a decision on the lending of loans is influenced by the close relationship/ family ties between the lender and the manager. However, such relationships/ways of doing business have led to problems of non-performing loans in domestic banks. The foreign banks in Jordan are less subject to this kind of business, which in turn could be viewed as a factor that enhances the cost efficiency of foreign banks. This finding could enhance the CBJ decision on allowing foreigners to own more that 50 per cent of Jordanian local banks.

[99] It should be noted that the literature on developed countries shows that the local banks are more efficient than foreign banks (e.g. Hasan and Hunter, 1996; Mahajan et al., 1996; Chang et al., 1998; De Young and Nolle, 1996; Berger et al., 2000; Sathye, 2001). According to these studies, foreign banks in developed countries finance their operations by depending on the purchasing of funds, which are more expensive than core deposits (Isik and Hassan, 2003).

Figure 6.5 Cost Efficiency of Domestic and Foreign banks

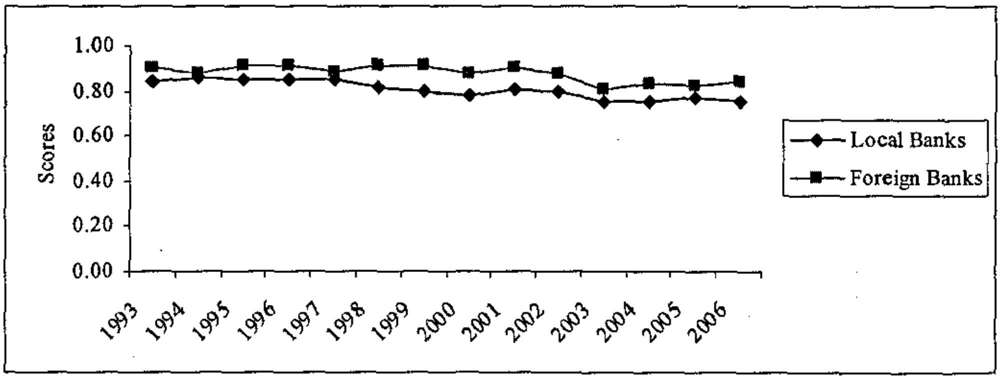


Table 6.17 Cost Efficiency of Domestic and Foreign Banks.

Year	Domestic Banks	Foreign Bank
1993	0.84	0.9
1994	0.86	0.88
1995	0.85	0.91
1996	0.85	0.91
1997	0.85	0.89
1998	0.82	0.91
1999	0.79	0.91
2000	0.78	0.87
2001	0.80	0.9
2002	0.80	0.88
2003	0.75	0.81
2004	0.75	0.83
2005	0.77	0.82
2006	0.75	0.84
Average	0.80	0.88

The difference in efficiency scores between foreign and domestic banks can be captured through profit efficiency. Table 6.18 indicates that the average profit efficiency for domestic and foreign banks over 1993-2006 is about 0.80. It should be noted there is no gap between the efficiency scores for domestic and foreign banks compared to the gap in cost efficiency scores between them. This is consistent with what we have reported earlier, that the dummy variable assigned for foreign bank (see Table 6.3) is negative but not significant. This suggests that there is no difference between foreign and domestic banks in terms of profit efficiency and that foreign banks in Jordan are more concerned with cost efficiency than profit efficiency. This conclusion could be valid to some extent since foreign banks, according to their policies, do not extend credit and advances to some risky sectors, such as loans for trading in stocks and securities. Moreover, all foreign banks from developed countries are prohibited from investing in stocks and securities. These restrictions could have negative impacts on foreign banks' profit efficiency. Furthermore, some foreign banks (e.g. HSBC, City Bank and Standard Chartered) apply their own credit scoring to grant loans to Jordanian clients. Since the data base for a credit bureau in Jordan is not well developed, applications for loans are often refused by foreign banks. This result is consistent with Yildirim et al. (2007) and Cadet (2008) who find that foreign banks in transition countries and Tahiti are more cost efficient but are not better than domestic banks in terms of profit efficiency. This could be attributed to foreign banks' being more conservative in granting loans, which in turn reduces their revenue and profits.

Figure 6.6 shows the trend of the alternative profit efficiency for domestic and foreign banks over the period 1993-2006. The graph suggests that both domestic and foreign banks follow the same trend, which means that market conditions in Jordan affected both foreign and domestic banks equally (see Chapter 4).

Figure 6.6 Profit Efficiency of Domestic and Foreign Banks

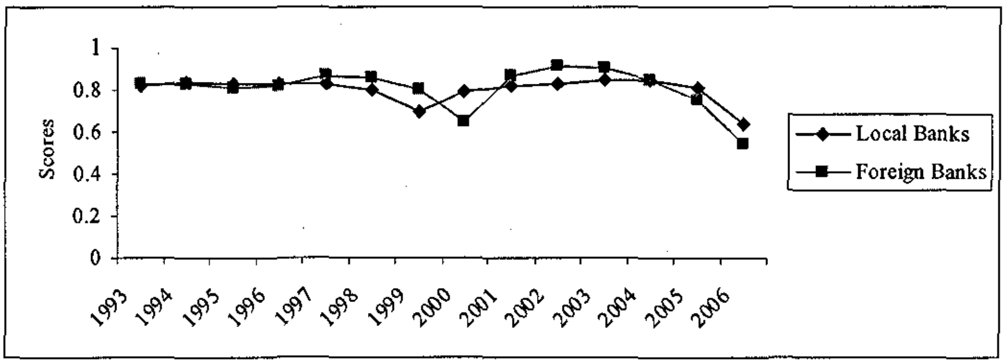


Table 6.18 Profit Efficiency of Domestic and Foreign Banks

Year	Domestic Banks	Foreign Banks
1993	0.82	0.82
1994	0.84	0.83
1995	0.83	0.81
1996	0.83	0.82
1997	0.83	0.87
1998	0.80	0.86
1999	0.70	0.80
2000	0.79	0.64
2001	0.82	0.86
2002	0.82	0.92
2003	0.85	0.90
2004	0.85	0.85
2005	0.81	0.75
2006	0.64	0.54
Average	0.80	0.80

6.6.3 Specialisation

The Jordanian banking system is made up of commercial banks, Islamic banks and investment banks (see Chapter 4 for details). Analysing the performance of each type of bank is important to see which type performs better. Figure 6.7 and Table 6.19 report the cost efficiency scores for the three types of bank operating in Jordan. Table 6.19 suggests that the Islamic banks are less cost efficient than commercial and investment banks. The average cost efficiency scores for commercial banks, investment banks and Islamic banks are 0.84, 0.80 and 0.79, respectively. This is consistent with (see Table 6.1) the dummy variable assigned to Islamic banks being positive and significant; this indicates that the cost inefficiency has increased within the Islamic banks. This finding is consistent with Kamaruddin et al. (2008) and Hassan (2005) who reported that Islamic banks are less cost efficient. Hassan (2005) also reported that Islamic banks operate in regulatory environments which are not supportive of their operation (this applies to Jordan, as there are no special regulations for Islamic banks). Hassan et al. (2003) found that Islamic banks operating in countries (e.g. Iran and Sudan) where the entire banking system is under Islamic Shariah (i.e. law) are more efficient than those in countries without special regulations for Islamic banks (e.g. Jordan). Moreover, the Islamic banks produce distinctive services and different product mixes requiring a more intense input use and more specialised staff[100]. In addition, there only two Islamic banks in Jordan and this leads to the Islamic banks having some market power in a country where more than 90% of its population is Muslim and they prefer to deal with Islamic banks. This market power enables Islamic banks to charge prices in excess of competitive levels and the managers may then take part of the benefits of the higher prices in the form of a quiet life (see Berger and Hannan, 1998), in which they do not work as hard to keep costs under control.

Figure 6.7 Cost Efficiency of Specialised Banks

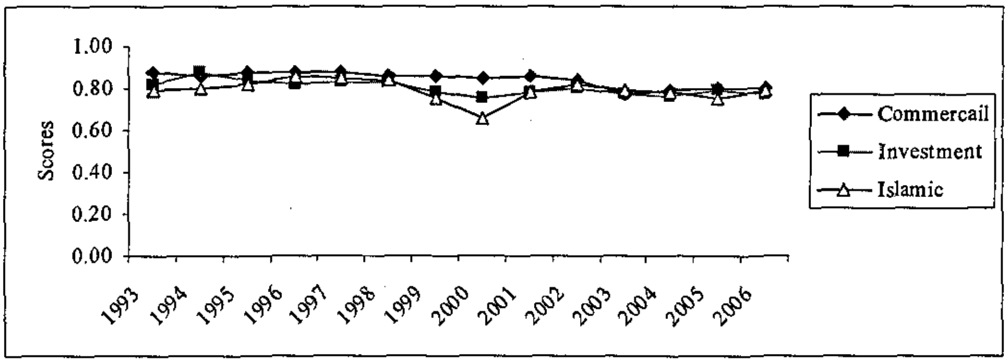


Table 6.19 Cost Efficiency of Specialised Banks

Year	Commercial	Investment	Islamic	Year	Commercial	Investment	Islamic
1993	0.87	0.82	0.79	2002	0.83	0.80	0.82
1994	0.86	0.87	0.80	2003	0.77	0.77	0.79
1995	0.88	0.84	0.82	2004	0.79	0.77	0.78
1996	0.88	0.81	0.86	2005	0.80	0.79	0.75
1997	0.87	0.83	0.85	2006	0.80	0.77	0.79
1998	0.86	0.83	0.84	Average	0.84	0.80	0.79
1999	0.86	0.78	0.75				
2000	0.85	0.76	0.66				
2001	0.86	0.78	0.78				

With regard to profit efficiency, Figure 6.8 and Table 6.20 suggest that Islamic banks are more profit efficient than commercial and investment banks. The average profit efficiency for Islamic banks is 0.90 compared to 0.79 and 0.80 for commercial and investment banks, respectively. The results are consistent with Hassan (2005) who reports that Islamic banks are more profit efficient the than other kinds of bank. The superiority of Islamic banks in profit efficiency can be attributed to the following:

[100] Islamic banks in Jordan do not grant money directly to the customer but finance what the client wants to purchase. For example, if the client wants to buy a car, the bank has to send an employee to check it and the car should be registered first in the name of the bank, which then sells it to the client. This process is accompanied with costs that do not exist in commercial and investment banks.

1. The Islamic banks in Jordan, as mentioned earlier, may be exercise market power by pricing their products and services more than other banks, because there are just two Islamic banks in Jordan.

2. The Islamic banks do not deal with risky assets such as derivatives and deal only with real assets, which in turn suggest that the Islamic banks are not facing the same risks as the other types of banks. Moreover, Islamic banking does not deal in debt trading and distances itself from market speculation that takes place in commercial and investment banking (Al-Hamzani, 2009).

3. The ratio of non-performing loans to loans for Islamic banks in Jordan on average does not exceed 5% over the period 1993-2006, whereas this ratio for commercial and investment banks exceeds 15%. This gives an indication that the Islamic banks are less susceptible to the asset quality problem, which in turn enhances their profit efficiency. These results could be realistic in the light that the Islamic banks across the world are less affected by the global financial crisis (Al-Hamzani, 2009).

Figure 6.8 Profit Efficiency of Specialised Bank

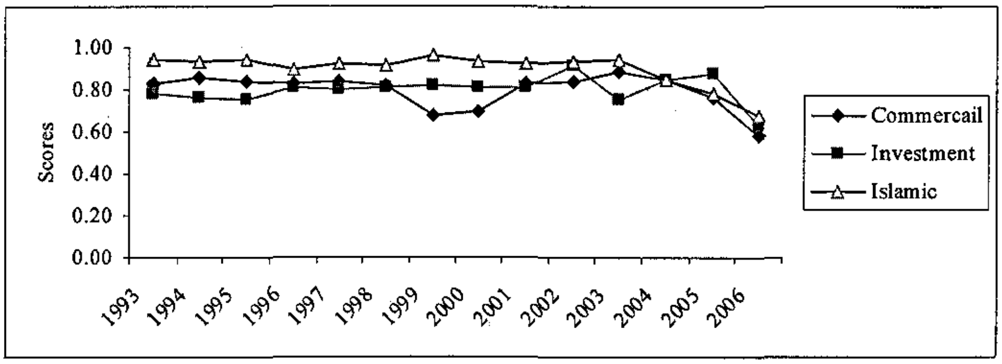


Table 6.20 Profit Efficiency of Specialised Banks

Year	Commercial	Investment	Islamic
1993	0.83	0.78	0.95
1994	0.85	0.76	0.94
1995	0.84	0.75	0.94
1996	0.83	0.81	0.90
1997	0.84	0.8	0.92
1998	0.82	0.81	0.91
1999	0.68	0.82	0.96
2000	0.69	0.81	0.93
2001	0.83	0.81	0.92
2002	0.84	0.91	0.94
2003	0.88	0.75	0.94
2004	0.85	0.85	0.85
2005	0.77	0.87	0.78
2006	0.58	0.63	0.67
Average	0.79	0.8	0.90

6.6.4 Bank Size

As shown earlier, the literature on the banking industry suggests that large banks enjoy several advantages compared to small banks. These include their ability to use more technology with less cost and their ability to exploit economies of scale and scope (Casu and Girardone, 2006). An analysis of the efficiency scores based on bank size could give the regulatory authority useful information regarding the relationship between bank size and efficiency (scores). Table 6.21 reports the cost efficiency scores based on different bank sizes[101]. In general, it suggests that the largest banks have the highest cost efficiency scores', e.g., the average cost efficiency score for banks with assets size more than 1000 MJOD is about 0.90, whereas the average of the cost efficiency scores for banks with assets size less than 500 MJOD is about 0.82.

As reported earlier (see Table 6.1), the asset size has an impact on the inefficiency of banks (i.e. the variable assigned for asset size is negative and significant, which means the big banks are less cost inefficient than small banks). This result is consistent with many studies that found a positive relationship between cost efficiency and bank size (e.g. Berger et al., 1993; Miller and Noulas, 1996; Altunbas et al., 2001; Al-Jarrah and Molyneux, 2003; Isik et al., 2004). This result also supports the view of some authors who advocate that large banks might have a more professional management team and/or might be more cost conscious due to greater pressure from the owners (Evanoff and Israilevich, 1991). This could be valid in the Jordanian banks' case since the majority of large bank shareholders are foreigners who place great pressure on the management to control costs. In addition, the large banks can use more efficient technology with less cost and have the ability to attract more specialised staff (Molyneux and Iqbal, 2005).

[101] This classification of asset sizes is used from different authors (e.g. Altunbas et al., 2001). For Jordan, CBJ classifies banks according to assets size as: 1-499.9MJOD small banks, 500-999.9 MJOD medium banks and more than 1000 MJOD big banks.

Table 6.21 Cost Efficiency Scores According to Asset Size (MJOD)

Year	1-99.9 MJOD	100-199.9 MJOD	200-299.9 MJOD	300-499.9 MJOD	500-999.9 MJOD	1000-2499.9 MJOD	2500-4999.9 MJOD	More than 5000 MJOD	Average per Year
1993	0.84	0.86	0.83	0	0.84	0.99			0.87
1994	0.87	0.86	0.83	0.83	0.84	1.00			0.87
1995	0.88	0.86	0.84	0.86	0.82	0.93			0.87
1996	0.86	0.82	0.9	0.87	0.86	0.88	0.97		0.88
1997	0.83	0.83	0.93	0.85	0.85	0.88	0.99		0.88
1998	0.85	0.85	0.87	0.8	0.77	0.86	1.00		0.86
1999	0.84	0.93	0.84	0.78	0.73	0.85	1.00		0.85
2000	0.81	0.8	0.82	0.86	0.75	0.84	0.97		0.84
2001	0.82	0.84	0.85	0.84	0.79	0.86	0.99		0.85
2002	0.83	0.98	0.81	0.86	0.78	0.78	0.99		0.86
2003	0.68	0.88	0.75	0.82	0.73	0.72	0.99		0.79
2004	0.82	0.71	0.92	0.81	0.72	0.71	0.99		0.81
2005	0.88	0.84	0.76	0.76	0.79	0.78	0.82		0.80
2006		0.78	0.84	0.79	0.8	0.75	0.69	0.93	0.80
Average	0.83	0.85	0.80	0.80	0.80	0.84	0.94	0.93	

MJOD: Millions of Jordanian dinar.

With regard to profit efficiency, Table 6.22 shows contradictory results compared to the cost efficiency scores. The small banks are more profit efficient than large banks. This could be interpreted in the light of the big two Jordanian banks which accounted for about 40% of the total Jordanian banks' assets, being dominated by foreign shareholders and, as reported earlier, foreigners are more concerned with issues of cost rather than profit issues. In addition, these two banks have proactive credit policies which prevent granting any loan without all the required documents from the clients. Moreover, the biggest Jordanian bank (Arab Bank), which has more than 100 branches outside Jordan, faces many problems in the US as a result of granting loans to the largest American energy company (Enron) which went into bankruptcy in 2001. This event affected negatively the profit of this bank. Furthermore, the large banks in Jordan hold high level of liquidity; the average liquidity ratio (cash and deposits at banks to total assets) for the large banks is about 60%, while for other banks it is about 44% (CBJ, 2006). An excess *liquidity in banks has a direct impact on the level of the banks' profits. Usually, liquid* assets bear zero or low interest rates, which in turn will have a negative effect on bank profit (Armah and Park, 1998).

Table 6.22 Profit Efficiency Scores According to Assets Size (MJOD)

Year	1-99.9 MJOD	100-199.9 MJOD	200-299.9 MJOD	300-499.9 MJOD	500-999.9	1000-2499.9 MJOD	2500-499.9 MJOD	More than 5000 MJOD	Average
1993	0.78	0.83	0.8		0.90	0.84			0.83
1994	0.77	0.83	0.8	0.80	0.90	0.87			0.85
1995	0.78	0.80	0.80	0.80	0.90	0.90			0.85
1996	0.84	0.84	0.80	0.70	0.90	0.85	0.94		0.84
1997	0.81	0.82	0.80	0.80	0.90	0.85	0.94		0.85
1998	0.84	0.87	0.80	0.70	0.80	0.77	0.88		0.82
1999	0.63	0.88	0.80	0.70	0.60	0.54	0.76		0.70
2000	0.83	0.83	0.70	0.90	0.70	0.69	0.50		0.74
2001	0.93	0.68	0.90	0.90	0.80	0.89	0.95		0.85
2002	0.93	0.92	0.90	0.90	0.90	0.69	0.89		0.87
2003	0.96	0.92	0.90	0.80	0.80	0.88	0.88		0.89
2004	0.89	0.79	0.90	0.90	0.90	0.66	0.81		0.84
2005	0.76	0.73	0.70	0.80	0.90	0.74	0.72		0.76
2006		0.61	0.50	0.50	0.70	0.63	0.49	0.54	0.57
Average	0.83	0.81	0.80	0.70	0.80	0.77	0.80	0.54	

MJOD: Millions of Jordanian dinar.

6.7 Scale Economies and Technological Change

6.7.1 Scale Economies

As mentioned in Chapter 5, a measure of economies of scale (SE) is given by the cost elasticity by differentiating the cost function with respect to outputs (i.e. y_k). This can be measured by the partial derivative of the estimated cost function (i.e. equation 5.27 in Chapter 5), with respect to the outputs (i.e. y_k) and can be shown as:

$$\frac{\partial TC}{\partial y_k} = \sum_{k=1}^{3}\delta_k + \sum_{k=1}^{3}\sum_{m=1}^{3}\delta_{km}\ln y_m + \sum_{n=1}^{2}\sum_{k=1}^{3}\eta_{nk}\ln(w_n / w_3) + \sum_{k=1}^{3}\zeta_{1k}\ln E$$
$$+ \sum_{k=1}^{3}\kappa_{1k}T + \sum_{k=1}^{3}\sum_{r=1}^{2}\omega_{kr}\ln c_r \quad (6.1)$$

Given the preferred SFA cost specification reported earlier (see Table 6.1), scale economies estimated for the Jordanian banks over the years 1993-2006 are shown in Table 6.23. The table shows the economies of scale for the banks according to different asset size groups for each year. Table 6.23 suggests that the average scale economies between 1993-2006 is about 6% (i.e. 1.06). Also, the table suggests that scale economies are prevalent for all banks with assets size less than 300 MJOD. Typically, scale economies for these banks range between 1% and 27%. Thus a 100% increase in the level of all outputs would, on average, lead to about a 99% to 73% increase in total costs, respectively. Also, Table 6.22 suggests that banks with assets' size exceeding 300 MJOD face diseconomies of scale, typically ranging from 2% to 32%. Thus a 100% increase in the level of all outputs would, on average, lead to about a 102% to 132% increase in total costs, respectively. The optimal bank sizes for the Jordanian banks are in the range of 200-500 MJOD. The magnitudes of the scale economies for the Jordanian banks are in accordance with previous studies (e.g. Berger et al., 1993; Altunbas et al., 2001), reporting widespread economies of scale for the smallest banks and diseconomies of scale for the largest banks.

Table 6.23 Scale Economies for Jordanian Banks 1993-2006

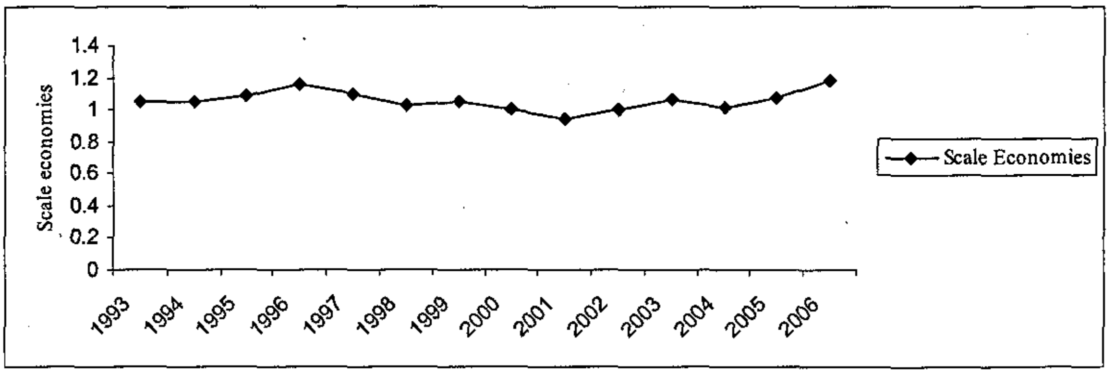
	Asset Sizes in MJOD								
	1-99.9	100-199.9	200-299	300-499	500-999	1000-2499	2500-4999	more than 5000	Average
1993	**0.7**	**0.88**	0.99		**1.29**	**1.39**			1.05
1994	**0.75**	**0.89**	1.02	0.98	**1.29**	**1.38**			1.05
1995	**0.87**	0.94	1.04	**1.06**	**1.3**	**1.34**			1.09
1996	**0.89**	**0.90**	**1.09**	**1.07**	**1.33**	**1.34**	**1.46**		1.15
1997	**0.71**	0.96	1.06	**1.06**	**1.17**	**1.26**	**1.44**		1.09
1998	**0.74**	**0.88**	0.97	1.04	**1.15**	**1.2**	**1.2**		1.02
1999	**0.68**	1.03	**0.92**	**1.05**	**1.1**	**1.16**	**1.41**		1.05
2000	**0.65**	**0.90**	0.96	**0.93**	**1.08**	**1.14**	**1.35**		1.00
2001	**0.63**	**0.87**	**0.80**	**0.93**	1.07	**1.11**	**1.21**		0.94
2002	**0.66**	1.06	0.94	**0.93**	**1.08**	**1.11**	**1.23**		1.00
2003	**0.77**	**1.18**	0.98	1.01	1.07	**1.13**	**1.27**		1.06
2004	**0.61**	**0.79**	1.06	1.02	**1.15**	**1.15**	**1.29**		1.01
2005	**0.84**	0.95	1.03	**1.07**	**1.1**	**1.22**	**1.29**		1.07
2006		0.99	1.04	**1.11**	**1.19**	**1.28**	**1.32**	**1.32**	1.18
Average	0.73	0.95	0.99	1.02	1.17	1.23	1.32	1.32	1.06

Values in bold statistically significant different from 1 at 5% level[102]

[102] In testing for the presence of scale economies, the null hypothesis is H_0: scale economies equal 1 and the alternative hypothesis is H_1: scale economies are not equal to 1. The testing is done by calculating the standard error (se) from the covariance matrix produced from the program Frontier 4.1. After calculating the se, we follow traditional hypothesis testing by calculating the value of the test statistic which equals 1-value of scale economies/standard error. If the value of the test statistic is less than the critical value at the 5 % level (i.e. ± 1.96), we accept the null hypothesis that the value of scale economies equals 1 and if the value of the test statistic is more than the critical value at 5% (i.e. 1.96) we reject the null hypothesis and accept the alternative hypothesis.

Analysing trend of the scale economies of Jordanian banks over 1993-2006 as shown by Figure 6.9 reveals that through the years 1993-2006, with the exception of the years 2000, 2001 and 2002, the Jordanian banks on average exhibit diseconomies of scale. This may be reflecting that deregulation has made it possible for banks to offer more products and services and alter the production process to offer more diverse products as a result of the removing of the restrictions on the scope of bank operations (e.g. on foreign currency operations; for more detail, see Table 4.3, Chapter 4).

Figure 6.9 Trend of Scale Economies of Jordanian Banks 1993-2006



The results suggest that in order to improve economies of scale efficiency, small banks should expand their scale of production, while large banks should concentrate on reducing their outputs. However, the CBJ regulations still tie the granting of loans to the level of banks' equities (see Table 4.4, Chapter 4) which means that the small banks with low levels of equities could not reap the benefits of any possible economies of scale. Additionally, the CBJ has been persistently trying to consolidate the banking industry by offering incentives to smaller banks to merge with others. However, such efforts have not been particularly successful, as small Jordanian banks have a strong tradition of family ownership and the owners are reluctant to pass control to another bank (Isik et al., 2004).

It should be noted that Evanoff and Israilevich (1995) saw confusion in the literature between two concepts: scale elasticity and scale efficiency. Scale elasticity is an elasticity associated with a particular output level and indicates the relative change in cost associated with an incremental change from this output level. Scale efficiency refers to the percentage the cost ought to change if a bank needs to move to minimum efficient scale[103]. Evanoff and Israilevich (1995) show that scale inefficiency (SI) can be measured as the percentage of the cost of the banks operating on constant returns to scale to the cost of banks operating on economies of scale. Evanoff and Israilevich (1995) derived the following equation[104] as a direct measure for scale inefficiency:

$$SI = e^{(0.5/s)(1-F_1)^2} - 1 \tag{6.2}$$

where SI is scale inefficiency, s is the second derivative of equation 6.1 and F the first derivative for equation 5.27 (i.e. equation 6.1). Thus, the scale inefficiency is a function of the first and the second derivatives of the cost function.

Table 6.24 reports the scale efficiencies from SFA and DEA (for calculation of scale efficiency according to DEA, see Chapter 5). Average scale efficiency for Jordanian banks is about 0.97 according to SFA and 0.92 according to DEA. It should be noted these results are consistent with the view of Berger et al. (1993) and Berger and Humphrey (1994, 1997) who indicated that scale inefficiencies are usually found to account for less than 5 per cent of banks' cost. Moreover, Berger and Humphrey (1994) indicated that the measuring of scale inefficiency in banking is a problematic issue because scale economies theoretically apply only to banks operating on the production possibility frontier. However, in the literature, scale economies are usually measured using data on all banks in the sample. The use of data from banks other than those on the frontier could confound scale effects with differences in X-efficiency (Berger et al., 1993).

[103]Minimum efficient scale can be defined as the output for a bank in the long run where the internal economies of scale have been fully exploited, and correspond to the minimum point of the U-shaped long average costs curve (Molyneux et al., 1996).

[104] For proof of the equation (6.2), see Evanoff and Israilevich (1995).

Table 6.24 Scale Efficiency for Jordanian Banks 1993-2006

Year	SFA Scale Efficiency	DEA Scale Efficiency
1993	0.96	0.95
1994	0.97	0.95
1995	0.98	0.95
1996	0.97	0.94
1997	0.97	0.92
1998	0.98	0.94
1999	0.98	0.93
2000	0.98	0.92
2001	0.98	0.92
2002	0.98	0.92
2003	0.98	0.89
2004	0.96	0.90
2005	0.98	0.90
2006	0.97	0.86
Average	0.97	0.92

6.7.2 Technological Change

As mentioned in Chapter 5, we have included the time trend (T) in the model to account for technological change in the Jordanian banking industry over the period 1993-2006. Baltagi and Griffin (1988), Kumbhaker and Lovell (2000) Altunbas et al. (2001) and Coelli et al. (2005) show that the technological change can be estimated by calculating the variation in total cost due to a given change in technology[105]. This can be measured by the partial derivative of the estimated SFA cost frontier (i.e. equation 5.27, Chapter 5), in respect of the time trend, and can be shown as:

$$\frac{\partial \ln TC}{\partial T} = \tau_1 + \tau_{11}T + \sum_{k=1}^{3} \kappa_k \ln y_k + \sum_{n=1}^{2} \theta_n \ln(w_n / w_3) \tag{6.3}$$

The measures of technical progress, which indicate the possible contribution of technical advances in reducing average banking costs across time for Jordanian banks 1993-2006, are reported in Table 6.25. This shows that technological change has made a positive contribution across Jordanian banks, reducing the real annual cost of production by around 1.3 %. Table 6.25 suggests that the annual rate of reduction in total cost attributed to technological change was around 2% in 1993, decreasing to 0.9%

[105] DeYoung (1997) stated that the technological change can shift the cost frontier in a number of ways. First, adopting the new low-cost technologies such as ATMs to substitute for the existing high-cost technology. Second, using the new computer systems that allow the banks to reduce the costs by the substitution of the physical capital by labour. Third, deregulation can also provide an opportunity to recognise inputs in a lower cost fashion.

in year 1997. After year 1997, the technical change increased slightly from 1.1% in 1998 to 1.7% in year 2004. However, the technological change slightly decreased from 1.2% in year 2005 to 0.5% in year 2006. These findings seem plausible because the banks in Jordan have invested heavily in technology; especially in the year 1997 (banks' fixed costs increased that year by approximately 25%). The Jordanian banks started computerising all their operations, introduced ATMs, and applied an online system of communication.

Table 6.25 Technological Change in the Jordanian Banking Industry 1993-2006

Year	Technological Change
1993	**-0.020**
1994	**-0.018**
1995	**-0.014**
1996	-0.011
1997	-0.009
1998	-0.011
1999	**-0.012**
2000	**-0.012**
2001	**-0.015**
2002	**-0.015**
2003	**-0.015**
2004	**-0.017**
2005	-0.012
2006	-0.005
Average	-0.013

Values in bold statistically significantly different from 0 at 5% level[106]

By adopting the terminology of Baltagi and Griffin (1988), Atunbas et al. (1999) and Kasman and Kirbas (2006), the technological change can be decomposed to:

1. Pure technical change $(\tau_1 + \tau_{11}T)$, the part related to time in equation 6.3.
2. Scale augmenting technical change $(\sum_{k=1}^{3} \kappa_k \ln y_k)$, the part related to outputs in equation 6.3.
3. Non-neutral technical change $(\sum_{n=1}^{2} \theta_n \ln(w_n / w_3))$, the part related to prices in equation 6.3.

Pure technological change accounts for the reduction in total costs over time due to technological changes. Scale augmenting technical change accounts for the reduction in cost due to efficient scale of production. Finally, non-neutral technical change reflects the reduction in total costs due to a variation in input prices. Table 6.26 suggests that the

[106] In testing for the presence of technological change, we follow the same procedures as for the scale economies.

main source for technological change for Jordanian banks over 1993-2006 is due to pure technical change.

Table 6.26 Decomposition of Technological Changes

Year	Pure Technological Change	Scale Augmentation Change	Non-Neutral Technological Change	Total Technological Change
1993	**-0.018**	-0.003	0.002	**-0.020**
1994	**-0.018**	-0.003	0.003	**-0.018**
1995	**-0.017**	0.000	0.003	**-0.014**
1996	**-0.016**	0.002	0.003	-0.011
1997	**-0.015**	0.001	0.005	-0.009
1998	**-0.014**	0.000	0.003	-0.011
1999	**-0.014**	0.000	0.001	**-0.012**
2000	**-0.013**	-0.001	0.002	**-0.012**
2001	**-0.012**	-0.001	-0.002	**-0.015**
2002	-0.011	0.000	-0.004	**-0.015**
2003	-0.010	0.001	-0.005	**-0.015**
2004	-0.010	-0.002	-0.005	**-0.017**
2005	-0.009	0.001	-0.004	**-0.012**
2006	-0.008	0.004	0.000	-0.005
Average	-0.013	0.000	0.000	-0.013

Values in bold statistically significantly different from 0 at the 5% level

6.8 Conclusion

This chapter presented the cost and the profit efficiency scores obtained from SFA and DEA. Based on the results of preferred models of SFA, the cost efficiency scores averaged around 83% between 1993-2006. Given the alternative and standard profit frontiers, the profit efficiency scores averaged 80% and 84%, respectively. The efficiency scores for the cost and the profit efficiency models have shown significant volatility between 1993-2006. Analysing the trend of the efficiency scores of Jordanian banks 1993-2006 has shown that the efficiency scores improved slightly 1993-1996, then worsened markedly 1997-2003 and improved slightly after 2003. Linking the deregulation processes put in place by the CBJ with the efficiency scores 1993-2006, we can note that the efficiency scores improved in the period characterised by deregulation of the interest rate (i.e. 1993-1996), whereas the deregulation processes put in place 1997-2001 had a negative impact on the Jordanian banks' efficiency scores. This period is characterised by deregulation of the scope of banks' products and services by allowing banks to produce a variety of products and services. This period of deregulation led to many Jordanian banks' becoming more risky, which in turn worsened the efficiency of Jordanian banks. After the year 2003, there was little improvement in the Jordanian banks' efficiency as a result of entry of many foreign banks into the Jordanian banking market. Based on the results of DEA, the cost and profit efficiency scores show almost the same trend of SFA efficiency scores. It could be argued that the efficiency scores for the Jordanian banks over the period 1993-1996 and 2003-2006 are improved slightly as a result of deregulation measures undertaken by the CBJ and the measures were put in place between 1997-2002 have markedly negative impacts on the efficiency levels of Jordanian banks (hypothesis 1). In general, the results indicate profit inefficiencies appear to be greater than cost inefficiencies. Banks therefore need to focus more on revenue generation, coupled with appropriate risk management practice and more prudential supervision from the CBJ regarding risky assets.

This chapter also presented the testing for research hypotheses 2-9. With respect to the ownership structure, we conclude that foreign banks are more cost efficient than domestic banks, but are not better than domestic banks in terms of profit efficiency (hypothesis 2). This could be attributed to foreign banks' greater concern in controlling cost than in generating profit from risky activities. Regarding specialisation, we found that Islamic banks are less cost efficient than commercial and investment banks but more profit efficient than commercial and investment banks (hypothesis 3). The Islamic banks in general produce different products and services needing more resource than used by commercial and investment banks. At the same time, Islamic banking in Jordan has only two banks, which in turn suggests that Islamic banks have some market power by setting their prices above those set by commercial and investment banks. This could motivate the CBJ to license new Islamic banks to improve the competition within Islamic banks. With respect to bank size, we found that large banks seem to be relatively more cost efficient and less profit efficient than small banks (hypothesis 4). This suggests that large banks enjoy several advantages in terms of cost efficiency. This includes their ability to use more efficient technology with less cost and to use more specialised staff. In terms of profit efficiency, it seems that large banks are more conservative in dealing with risky assets, which in turn affects their profit efficiency. The new banks were found to be more cost and profit efficient than old banks (hypothesis 5). Regarding corporate control, the agency problem does not hold in the Jordanian banks (hypothesis 6). Regarding market structure, the traditional hypothesis of the SCP is not hold, where the efficient hypothesis is hold for the Jordanian banks (hypothesis 7). It found that the volume of non-performing loans has a negative impact on both of cost and profit of the Jordanian banks (i.e. an increase in the non-performing loan increases costs and decreases profits) (hypothesis 8). The level of capital adequacy has no impact on the level of banks' costs and profits (hypothesis 9).

This chapter also compared the cost and the profit efficiency scores derived from the two different methodologies (i.e. DEA and SFA) using five consistency checks. These were: comparable mean; ranking; identification of the best and worst banks; stability over time; and the relation to financial ratios performance measures. To some extent, there is reasonable consistency between the efficiency scores generated from the two methodologies as both models: generated almost comparable means; placed the banks in the same rank order; identified the best and the worst performing banks; and provided consistent stability over time. Regarding the relation of the efficiency scores and financial ratios performance measures, there is a low correlation between the frontier scores and the financial ratios performance measures.

This chapter also presented the main characteristics of the most and least efficient banks in relation to: the CAMEL rating system; ownership structure; specialisation; and bank size. With regard to the CAMEL rating system, the most cost and the profit efficient banks also obtained good financial indicators used by the regulatory authorities.

This chapter also presented scale economies and scale efficiency for Jordanian banks. Aligned with the literature, scale efficiency did not exceed 5% in the Jordanian banking industry. The results have shown that small banks are facing economies of scale and large banks diseconomies of scale. According to the scale economies' results for Jordanian banks, the optimal bank size is in the range of 200-500 MJOD.

Finally, this chapter presented the technological change in Jordanian banks. The results show that technical change has made a positive contribution across Jordanian banks, reducing the real annual cost of production by about 1.3 %.

Chapter 7 Conclusion

7.1 Introduction and Summary of Findings

This thesis seeks to investigate the efficiency of Jordanian banks in the context of the banking sector deregulation policies implemented in Jordan in the early 1990s. Prior to the deregulation, the Jordanian banking industry served as an agent of the government and channelled investment funds to selected sectors under the country's economic development policy. Moreover, the CBJ implemented a direct management control system to determine the size, cost and direction of credit facilities and the structure of the financial portfolio of the banks. However, by the end of 1989 the Jordanian economy faced a major crisis when the Jordanian Dinar (JOD) suffered a major devaluation (i.e. the JOD lost 51% of its value against the US Dollar), total government debt reached 197 per cent of GDP and the country's reserves of foreign currency declined sharply (Isik et al., 2004). Consequently the banking sector suffered from problems such as an increase in the ratio of non-performing loans and this subsequently led to serious consequences for the banking industry and the collapse of many Jordanian Banks (e.g. Petra Bank, Islamic National Bank, Amman Bank) (Al-Jarrah, 2002). Therefore, following criticism of the government policies the Jordanian government started to co-operate with the International Monetary Fund (IMF) and the World Bank (WB) in the early 1990s, in order to develop and liberalise its banking system. Jordan thus witnessed a series of financial reforms and deregulation measures including removing the ceiling in interest rates, freeing foreign exchange controls, allowing non-Jordanians to own more than 50% of Jordanian bank stocks, decreasing the entry restrictions on foreign banks, lowering banks' required reserve ratio and giving banks' management great autonomy in deciding the product mix of their banks. The main aims of the CBJ in liberalising the banking system were to promote its soundness, efficiency and competition, through measures such as improving resource' allocation and allowing banks to have more operating options: the government and CBJ hoped that profitability, lower intermediation costs and enhanced customer service would be achieved by the banking sector as a direct result of such liberalisation. The emphasis on the deregulation of the banking sector in Jordan is due to the banking sectors pivotal role in the economy by facilitating transactions, mobilising savings and allocating capital across time and space.

The main objective of this thesis was to examine whether the efficiency of banks has improved as a result of the deregulation. Moreover, the thesis aimed to test many conceptual issues (e.g. the level of risk taken by banks, ownership structure, specialisation, corporate control and market conditions) and their impact on banks' efficiency.

This research used a parametric approach (SFA) and a data set comprising all the Jordanian banks, covering the period 1993-2006. Three distinct economic efficiency concepts (cost, standard profit and alternative profit) were used to measure efficiency for Jordanian banks. In this research, one-stage analysis was used by introducing directly into the model variables that account for internal bank-specific characteristics (e.g. risks, ownership structure, age of bank, size of banks, corporate control) and market conditions (e.g. the level of concentration). This approach allows estimating efficiency scores that take into account differences between banks and capturing the factors that could explain variations in the efficiency of banks in Jordan. In the specification of the cost and the profit frontiers, various contemporary methodologies were followed that use a variety of hypothesis testing to arrive at the preferred model specification(s). Based on the preferred cost/profit model(s), the efficiency scores for Jordanian banks were estimated. In order to test the consistency of the efficiency estimates derived from the parametric approach (SFA), this research also used a nonparametric approach, (DEA), to measure efficiency scores for the banks. Despite major differences in the underlying assumptions of parametric and nonparametric methodologies, there was reasonable consistency between the efficiency scores generated from the two approaches. For example, both generated almost comparable means; placed the banks in the same rank order; identified the same best and worst performing banks; and provided a consistent ranking for each bank over time.

With regard to the main aim of this study which was to examine whether the efficiency of banks has improved as a result of the deregulation, this thesis found that substantial cost and profit inefficiencies existed in Jordanian banks. The average cost inefficiency of the Jordanian banks during 1993-2006 was around 17% (for both parametric and nonparametric approaches), whereas the average profit inefficiency was around 20% for the parametric approach and 25% for the nonparametric approach. Therefore, Jordanian banks could produce the same level of outputs with approximately a 17% saving in costs and a 25% increase in profits. Additionally, the results indicated that the profit inefficiencies appear to be even greater than the cost inefficiencies. Therefore, given these results banks might be best advised to focus more on revenue generation with sensible levels of risks and be subject to more prudential supervision from the CBJ regarding risky assets.

This research finds that the average efficiency scores for Jordanian banks have fallen over the period 1993-2006. For example, referring to the results in Chapter 6, we find that the average level of cost efficiency fell from 86% (SFA) and 84% (DEA) in 1993 to around 79% (SFA) and 77% (DEA) in 2006. Regarding profit efficiency, the average efficiency scores fell from 82% (SFA) and 84% (DEA) in 1993 to around 59% (SFA) and 77% (DEA) in 2006.

Linking the deregulation process put in place by the CBJ with the efficiency scores between 1993-2006, we can note that the efficiency scores improved in the period characterised by deregulation of the interest rate (i.e. 1993-1996) by about 1% (for SFA cost efficiency) and about 2% (for SFA profit efficiency).

However, the deregulation process put in place 1997-2001 had negative impacts on Jordanian banks' efficiency scores. The SFA cost efficiency scores fell on average by 8%, where the SFA profit efficiency scores fell by about 10%. This period is characterised by deregulation of the scope of banks' products and services by allowing banks to produce a variety of them. This stage of deregulation led to many Jordanian banks' becoming more riskier, which in turn worsened the efficiency scores of Jordanian banks. The prudential regulations at this period operating within the CBJ were possibly not adequate to cope with the attitude of banks towards expanding their operation with risky assets, which in turn led Jordanian banks to become subject to an increasing level of risks. This led to raising the percentage of non-performing loans from 20% in 1996 to an average of 35%, 1998-2000.

However, after 2003, there was little improvement in the Jordanian banks' level of efficiency as a result of: (i) the entry of many foreign banks into the Jordanian banking market and (ii) the CBJ worked from the year 2001 to strengthen its regulation on corporate governance and the issues relating to risk management (e.g. adopting Basel II). Referring to additional research questions (Chapter 1, p.4) and the hypotheses outlined in Chapters 4 and 5 this research also found:

- The level of capital adequacy ratio has no impact on the level of banks' costs (profits). Moreover, the most efficient banks have a lower level of non-performing loans, while the least efficient banks have a higher level.
- Foreign banks are more cost efficient than domestic banks. Based on profit efficiency, there is no significant difference between foreign and domestic banks.
- Islamic banks are less cost efficient than commercial and investment banks, although they are more profit efficient than commercial and investment banks.
- Large banks seems to be relatively more cost efficient, but in term of profit efficiency small banks show the greatest level of efficiency.
- New banks seem to be relatively more cost and profit efficient compared to old banks. Possibly because the old banks may suffer from bureaucracy and clumsy formal organisation, whilst newly-established banks employ the most efficient technology available.
- The agency problem does not hold in the Jordanian banking market because most of the banks are closely knit, where owners are strongly involved in management.
- Concentration does not increase cost inefficiency, whereas market share decreased the cost and profit inefficiency.

This research found that there is a high correlation between efficiency scores generated from SFA and the CAMEL rating system indicators used by the CBJ. The most cost and profit efficient banks obtained good financial indicators used by the CBJ in relation to CAMEL rating system. For example, most efficient banks have: a low level of non-performing loans, a lower cost-income-ratio, lower operating expenses, a higher liquidity ratio and less dependence on purchased funds, higher ROE and ROA ratios.

There is low correlation between cost and profit efficiency scores. This suggests that banks with low cost efficiency tend to have high profit efficiency that offsets it. Moreover, the difference in the rank order of banks under profit efficiency and cost efficiency could relate to the attitudes of management towards optimisation objectives and risks. Some banks may be concerned with controlling costs and others revenue generation.

7.2 Policy Implications

In the light of the main aim of this research, which was to investigate the impact of deregulation on the level of efficiency of the Jordanian banks, it could be argued that in general the deregulation implemented did not have a noticeable impact on the improvement in banking sector efficiency, especially over the period 1997-2002. The implication for government policy is that the conventional wisdom which holds that deregulation always improves efficiency may be incorrect. Industry conditions prior to deregulation and the existence of adequate prudential regulation and supervisory procedures from the CBJ are also crucial for the success of such deregulation measures. Therefore, before introducing any deregulation measures, the CBJ should ensure that it has adequate prudential regulations that can prevent banks from engaging in risky activities coupled with appropriate risk management practices within banks.

Another policy implication from this study is that the entry of three new banks to the Jordanian market enhanced the level of competition in the Jordanian banking sector. Possibly regulators should encourage more competition amongst banks as a source of ongoing efficiency and innovation within the banking market. Moreover, as there are only two Islamic banks in Jordan and these banks are suffering substantial cost inefficiencies, this might encourage the CBJ to increase the number of Islamic banks to improve competition within Islamic banks sector.

In addition to measuring inefficiency levels, this research also sought to identify the sources and causes of inefficiency. In this respect the results suggest that the main characteristics of inefficient banks include high level of non-performing loans, high cost-income-ratio, dependency on purchasing funds and low liquidity ratio. This finding could help the CBJ to design appropriate policies to improve the performance of inefficient banks.

A final but very important conclusion in light of the high correlation between the efficiency scores generated from the frontier approaches and the CAMEL rating system used by the CBJ, this could have a good implication for the CBJ for adopting efficiency scores for Jordanian banks as a tool that supports the CBJ decision on rating banks according to the CAMEL system.

7.3 Limitations of this Research and Future Research

This research used the parametric approach (SFA) as the main methodology and the nonparametric approach (DEA) to check for consistency of efficiency scores generated from SFA. However, as mentioned in Chapter 2, inefficiency is not observable and one can never be sure to get the correct values. Moreover, inefficiency estimates can vary quite strongly depending on the model specification. Therefore, any benchmarking analysis should not be based purely on one method but a combination of different techniques should be used to set standards. For example, in addition to SFA and DEA future research in this area might want to consider, despite any shortcoming, additional approaches such as DFA and TFA.

Despite the growth of off-balance sheet activities in Jordanian banks as an important source of income, especially after 2000, this research does not include off-balance sheet items (as outputs) because suitable data are not available for the years 1993-1998.

Additionally, an area of research deserving attention concerns efficiency comparisons among different countries. It might be interesting therefore to carry out similar efficiency research over all Arabian countries, (as per Europe), to compare banking sector efficiency scores across different Arabian regions. However, a lack of data on various Arabic banking countries may make this impractical.

Finally, an interesting area for future research is the estimation of cost and profit efficiency scores for the Jordanian banks after 2007 to see to what extent the global financial crises has affected (positively or negatively) the level of Jordanian banks' efficiency.

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Appendices

Appendix 6.1 Cost Efficiency Scores for Jordanian Banks (SFA) 1993-2006

Bank Name	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Bank Average	SD
ABC	0.95	0.93	0.92	0.93	0.86	0.86	0.84	0.81	0.85	0.79	0.73	0.74	0.67	0.70	0.83	0.09
Amman Bank	0.81	0.77	0.82	-											0.80	0.02
Arab Bank	0.99	1.00	0.96	0.97	0.99	1.00	1.00	0.97	0.99	0.99	0.99	0.99	0.98	0.93	0.98	0.02
Arab Egyptian Bank	0.79	0.77	0.78	0.77	0.72	0.81	0.80	0.80	0.76	0.69	0.65	0.67	0.70	0.70	0.74	0.05
Arab Investment Bank	0.82	0.80	0.78	0.74	0.81	0.77	0.77	0.67	0.83	0.80	0.72	0.68	0.74	0.70	0.76	0.05
Arabic Islamic Bank						0.94	0.88	0.72	0.85	0.89	0.87	0.83	0.81	0.84	0.85	0.06
Audi												0.85	0.82	0.89	0.85	0.04
Business Bank	0.84	0.87	0.82	0.82											0.84	0.02
Cairo Amman Bank	0.83	0.91	0.99	0.88	0.89	0.79	0.78	0.76	0.83	0.75	0.72	0.68	0.70	0.64	0.80	0.10
City Bank	0.85	0.82	0.97	0.95	0.95	0.94	0.91	0.88	0.97	0.98	0.88	0.92	0.83	0.93	0.91	0.05
Export Bank						0.86	0.95	0.95	0.90	0.87	0.88	0.93	0.89	0.76	0.89	0.06
Housing Bank	0.90	0.88	0.90	0.88	0.88	0.86	0.85	0.84	0.86	0.80	0.72	0.68	0.67	0.69	0.81	0.09
HSBC	0.97	0.95	0.98	0.96	0.96	1.00	0.97	0.94	0.99	0.97	0.91	0.89	0.91	0.94	0.95	0.03
Jordan Bank	0.75	0.75	0.74	0.86	0.85	0.73	0.71	0.73	0.75	0.74	0.70	0.68	0.71	0.73	0.74	0.05
Jordan Bank for Investment and Finance	0.82	0.97	0.96	0.97	0.95	0.90	0.85	0.86	0.87	0.76	0.80	0.82	0.85	0.80	0.87	0.07
Jordan Gulf Bank	0.74	0.68	0.73	0.76	0.73	0.78	0.78	0.80	0.81	0.71	0.62	0.61	0.67	0.74	0.73	0.06
Jordan Islamic Bank	0.79	0.80	0.82	0.86	0.85	0.73	0.62	0.60	0.71	0.75	0.71	0.73	0.70	0.74	0.74	0.08
Jordan Kuwait Bank	0.91	0.89	0.91	0.90	0.87	0.87	0.85	0.90	0.86	0.87	0.81	0.81	0.95	0.86	0.88	0.04
Kuwait National												0.77	0.88	0.88	0.84	0.06
Lebanon												0.98	0.99	0.84	0.94	0.08
National Bank	0.82	0.77	0.77	0.77	0.82	0.79	0.79	0.78	0.78	0.75	0.71	0.72	0.71	0.67	0.76	0.04
Philadelphia Bank	0.80	0.99	0.80	0.75	0.78	0.90	0.74	0.66	0.66						0.79	0.11
Societe General	0.97	0.92	0.87	0.88	0.87	0.79	0.94	0.81	0.82	0.83	0.74	0.72	0.70	0.72	0.83	0.09
Standard Charter	0.94	0.92	0.93	0.94	0.94	0.92	0.90	0.86	0.89	0.93	0.77	0.79	0.76	0.91	0.89	0.06
Union Bank	0.84	0.84	0.83	0.80	0.78	0.73	0.78	0.83	0.78	0.85	0.78	0.79	0.79	0.80	0.80	0.03
Average per year	0.86	0.86	0.86	0.86	0.86	0.85	0.83	0.81	0.84	0.83	0.77	0.79	0.79	0.79	0.83	

Appendix 6.2 Alternative Profit Efficiency Scores for Jordanian Banks (SFA) 1993-2006

Bank Name	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Bank Average	SD
ABC	0.92	0.90	0.78	0.81	0.88	0.86	0.82	0.81	0.88	0.90	0.92	0.87	0.92	0.65	0.85	0.07
Amman Bank	0.75	0.66	0.73												0.71	0.05
Arab Bank	0.84	0.87	0.94	0.94	0.94	0.88	0.76	0.49	0.95	0.89	0.88	0.81	0.90	0.54	0.83	0.14
Arab Egyptian Bank	0.75	0.76	0.75	0.86	0.82	0.89	0.79	0.84	0.94	0.94	0.91	0.84	0.78	0.40	0.80	0.13
Arab Investment Bank	0.85	0.82	0.84	0.89	0.84	0.93	0.90	0.94	0.92	0.95	0.88	0.87	0.71	0.50	0.85	0.12
Arabic Islamic Bank						0.89	0.96	0.93	0.92	0.96	0.97	0.92	0.69	0.71	0.57	0.11
Audi												0.63	0.53	0.42	0.53	0.10
Business Bank	0.94	0.94	0.86	0.83											0.89	0.06
Cairo Amman Bank	0.65	0.79	0.79	0.78	0.89	0.89	0.72	0.75	0.59	0.85	0.92	0.93	0.92	0.83	0.81	0.10
City Bank	0.91	0.93	0.78	0.84	0.87	0.85	0.92	0.91	0.89	0.92	0.92	0.93	0.58	0.38	0.83	0.16
Export Bank						0.92	0.85	0.84	0.89	0.91	0.87	0.84	0.74	0.61	0.83	0.10
Housing Bank	0.91	0.93	0.87	0.85	0.85	0.77	0.54	0.69	0.89	0.91	0.88	0.78	0.53	0.49	0.78	0.16
HSBC	0.73	0.69	0.88	0.68	0.88	0.93	0.72	0.53	0.83	0.91	0.91	0.94	0.95	0.76	0.81	0.13
Jordan Bank	0.74	0.87	0.84	0.70	0.82	0.77	0.68	0.80	0.96	0.85	0.91	0.93	0.87	0.69	0.82	0.09
Jordan Bank for Investment and Finance	0.91	0.89	0.80	0.83	0.83	0.75	0.84	0.92	0.91	0.84	0.62	0.71	0.96	0.54	0.81	0.12
Jordan Gulf Bank	0.73	0.90	0.88	0.82	0.65	0.67	0.63	0.84	0.80	0.44	0.95	0.90	0.85	0.48	0.75	0.16
Jordan Islamic Bank	0.95	0.94	0.94	0.90	0.92	0.93	0.96	0.94	0.93	0.91	0.92	0.78	0.87	0.64	0.89	0.09
Jordan Kuwait Bank	0.90	0.83	0.85	0.85	0.83	0.68	0.69	0.73	0.85	0.83	0.96	0.97	0.87	0.83	0.83	0.09
Kuwait National												0.88	0.76	0.68	0.77	0.10
Lebanon												0.85	0.81	0.61	0.16	0.13
National Bank	0.82	0.86	0.82	0.82	0.76	0.58	0.03	0.43	0.54	0.47	0.47	0.43	0.48	0.38	0.56	0.23
Philadelphia Bank	0.67	0.66	0.66	0.75	0.76	0.71	0.70	0.64	0.49						0.67	0.08
Societe General	0.82	0.85	0.90	0.92	0.86	0.90	0.56	0.83	0.93	0.93	0.97	0.94	0.80	0.62	0.85	0.12
Standard Chartered	0.91	0.83	0.84	0.90	0.90	0.82	0.76	0.22	0.67	0.96	0.90	0.92	0.74	0.47	0.78	0.20
Union Bank	0.73	0.78	0.75	0.75	0.78	0.84	0.84	0.73	0.90	0.94	0.75	0.96	0.95	0.85	0.83	0.09
Average per year	0.82	0.84	0.83	0.83	0.84	0.82	0.73	0.74	0.83	0.86	0.87	0.85	0.78	0.59	0.80	

Appendix 6.3 Standard Profit Efficiency Scores for Jordanian Banks (SFA) 1993-2006

Bank Name	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Bank Average	S.D
ABC	0.88	0.87	0.90	0.91	0.92	0.86	0.82	0.93	0.88	0.90	0.95	0.95	0.88	0.93	0.90	0.04
Amman Bank	0.60	0.58	0.55												0.58	0.03
Arab Bank	0.88	0.90	0.94	1.00	0.83	0.70	0.60	0.61	0.99	0.89	0.86	0.99	0.93	0.79	0.85	0.13
Arab Egyptian Bank	0.97	0.92	0.89	0.92	0.89	0.96	0.84	0.84	0.99	0.94	0.82	0.85	0.85	0.85	0.89	0.05
Arab Investment Bank	0.77	0.75	0.66	0.75	0.73	0.75	0.77	0.81	0.79	0.82	0.81	0.82	0.72	0.77	0.77	0.04
Arabic Islamic Bank						1.00	0.59	0.62	0.51	0.88	0.86	0.81	0.63	0.85	0.75	0.16
Audi												0.77	0.75	0.92	0.81	0.09
Business Bank	0.88	0.96	0.87	0.69											0.85	0.11
Cairo Amman Bank	0.75	0.79	0.93	0.93	0.94	0.87	0.78	0.80	0.62	0.76	0.87	0.80	0.93	0.78	0.83	0.09
City Bank	0.87	0.73	0.84	0.92	0.98	0.92	0.95	0.97	0.92	1.00	0.99	0.91	0.87	0.74	0.90	0.08
Export Bank						0.90	0.91	0.97	1.00	0.96	1.00	0.94	0.73	0.87	0.92	0.08
Housing Bank	0.96	0.97	0.94	0.98	0.99	0.92	0.71	0.88	0.92	0.86	0.85	0.96	0.67	0.76	0.88	0.10
HSBC	0.76	0.80	0.76	0.75	0.69	0.98	0.99	0.73	0.88	0.86	0.77	0.82	0.99	0.57	0.81	0.12
Jordan Bank	0.70	0.77	0.79	0.84	0.70	0.79	0.76	0.93	0.96	0.85	0.89	0.99	0.93	1.00	0.85	0.10
Jordan Bank for Investment and Finance	0.93	0.96	0.86	0.94	0.96	0.86	0.94	0.99	0.89	0.77	0.65	0.79	0.94	0.95	0.89	0.10
Jordan Gulf Bank	0.78	0.78	0.89	0.89	0.98	0.78	0.89	0.98	0.86	0.54	0.93	0.81	0.67	0.98	0.84	0.12
Jordan Islamic Bank	0.75	0.96	0.94	0.99	0.87	0.85	0.78	0.80	0.69	0.85	0.79	0.66	0.99	0.74	0.83	0.11
Jordan Kuwait Bank	0.97	0.88	0.89	0.99	0.88	0.94	0.83	0.88	0.90	0.78	0.93	0.95	1.00	0.98	0.91	0.06
Kuwait National												0.88	0.73	0.71	0.77	0.09
Lebanon												1.00	0.82	0.99	0.94	0.10
National Bank	0.79	0.68	0.70	0.77	0.71	0.73	0.05	0.63	0.61	0.51	0.56	0.61	0.96	0.72	0.64	0.18
Philadelphia Bank	0.75	0.78	0.85	0.83	0.91	0.99	0.62	0.84	0.69						0.81	0.11
Societe General	0.88	0.85	0.86	0.92	0.91	1.00	0.69	0.96	0.93	0.76	1.00	0.94	0.81	0.94	0.89	0.09
Standard Chartered	0.96	0.85	0.81	0.88	0.97	0.96	0.94	0.37	0.85	0.99	0.96	0.92	0.88	0.96	0.88	0.16
Union Bank	0.74	0.86	0.84	0.85	0.67	0.93	0.69	0.86	0.92	0.86	0.87	1.00	0.76	0.95	0.84	0.10
Average per year	0.83	0.83	0.84	0.88	0.86	0.88	0.76	0.82	0.84	0.83	0.86	0.87	0.84	0.85	0.84	

Appendix 6.4 Cost Efficiency Scores for Jordanian Banks (DEA) 1993-2006

Bank Name	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Bank Average	SD
ABC	1.00	0.95	0.90	0.79	0.93	0.84	0.75	0.83	0.80	0.79	0.69	0.74	0.73	0.82	0.83	0.09
Amman Bank	0.66	0.54	0.67	0.46											0.58	0.10
Arab Bank	0.99	0.99	1.00	1.00	0.99	1.00	1.00	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.00
Arab Egyptian Bank	0.94	0.82	0.82	0.72	0.83	0.79	0.79	0.94	0.93	0.99	0.84	0.85	0.86	0.97	0.86	0.08
Arab Investment Bank	0.84	0.78	0.76	0.84	0.84	1.00	0.81	0.91	0.83	0.88	0.78	0.73	0.76	0.86	0.83	0.07
Arabic Islamic Bank						1.00	0.62	0.70	1.00	1.00	1.00	0.96	0.98	0.84	0.90	0.15
Audi												0.42	0.63	0.77	0.60	0.18
Business Bank	0.96	0.79	1.00	1.00											0.94	0.10
Cairo Amman Bank	0.93	1.00	1.00	1.00	0.84	0.89	0.80	0.79	0.77	0.77	0.70	0.66	0.70	0.72	0.83	0.12
City Bank	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00
Export Bank						1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.64	0.00
Housing Bank	1.00	1.00	1.00	0.99	1.00	0.99	0.99	0.99	0.99	0.97	0.96	0.98	0.96	0.99	0.99	0.01
HSBC	0.96	0.97	0.99	0.80	1.00	0.83	0.79	0.85	0.79	0.75	0.70	0.77	0.71	0.64	0.82	0.11
Jordan Bank	0.83	0.77	0.80	0.80	0.76	0.82	0.70	0.79	0.70	0.68	0.66	0.61	0.60	0.72	0.73	0.08
Jordan Bank for Investment and Finance	1.00	1.00	1.00	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00
Jordan Gulf Bank	0.68	0.82	0.90	0.73	0.80	0.79	0.67	0.86	0.96	0.72	0.64	0.45	0.62	0.77	0.74	0.13
Jordan Islamic Bank	1.00	1.00	1.00	1.00	1.00	1.00	0.68	0.71	0.72	0.71	0.71	0.75	0.71	0.76	0.84	0.15
Jordan Kuwait Bank	0.97	0.99	0.97	0.87	1.00	0.80	0.86	0.95	0.85	0.89	0.84	0.88	0.99	0.98	0.92	0.07
Kuwait National												1.00	1.00	1.00	1.00	0.00
Lebanon												0.56	1.00	0.93	0.83	0.23
National Bank	0.99	0.89	0.88	0.88	0.92	0.91	0.93	0.87	0.79	0.78	0.70	0.73	0.69	0.71	0.83	0.10
Philadelphia Bank	0.83	0.83	0.81	0.58	0.90	0.66	0.55	0.61	0.80						0.73	0.13
Societe General	0.97	0.94	0.93	0.88	0.88	0.65	0.67	0.77	0.82	0.81	0.73	0.62	0.67	0.81	0.80	0.12
Standard Chartered	1.00	0.96	0.94	0.99	1.00	0.88	0.85	0.84	0.81	0.82	0.88	0.84	0.87	0.77	0.89	0.08
Union Bank	0.89	0.85	1.00	1.00	1.00	0.69	0.73	0.83	0.84	0.85	0.82	1.00	1.00	1.00	0.89	0.11
Average per year	0.92	0.89	0.92	0.87	0.93	0.88	0.81	0.86	0.87	0.86	0.82	0.80	0.84	0.87		

Appendix 6.5 New Cost Efficiency Scores for Jordanian Banks (DEA) 1993-2006

Bank Name	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Bank Average	S.D
ABC	0.80	0.84	0.79	0.75	0.78	0.79	0.77	0.78	0.68	0.67	0.60	0.65	0.73	0.71	0.74	0.07
Amman Bank	0.46	0.47	0.46												0.46	0.01
Arab Bank	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.97	1.00	0.01
Arab Egyptian Bank	0.67	0.67	0.72	0.65	0.59	0.83	0.83	0.86	0.69	0.66	0.51	0.51	0.99	0.72	0.71	0.13
Arab Investment Bank	0.79	0.72	0.84	0.88	0.96	0.85	0.84	0.96	0.88	1.00	0.93	0.67	0.74	0.75	0.84	0.10
Arabic Islamic Bank						0.93	0.93	0.72	0.96	1.00	1.00	1.00	1.00	1.00	0.95	0.09
Audi												0.98	0.57	0.57	0.71	0.24
Business Bank	1.00	0.99	1.00	1.00											1.00	0.01
Cairo Amman Bank	0.84	1.00	1.00	0.89	0.84	0.75	0.75	0.76	0.60	0.61	0.55	0.57	0.65	0.57	0.74	0.16
City Bank	1.00	1.00	1.00	0.99	1.00	1.00	1.00	1.00	1.00	0.79	1.00	0.77	0.92	1.00	0.96	0.08
Export Bank						1.00	1.00	1.00	0.85	1.00	1.00	0.77	0.88	0.61	0.90	0.14
Housing Bank	1.00	1.00	0.99	0.99	1.00	1.00	0.99	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00
HSBC	0.99	0.76	0.80	0.77	0.70	0.77	0.75	0.80	0.85	0.83	0.78	0.82	0.79	0.63	0.79	0.08
Jordan Bank	0.87	0.84	0.80	0.89	0.77	0.74	0.71	0.79	0.64	0.58	0.67	0.64	0.80	0.68	0.74	0.09
Jordan Bank for Investment and Finance	1.00	1.00	0.99	1.00	1.00	1.00	1.00	1.00	1.00	0.85	0.93	0.83	0.89	0.91	0.96	0.06
Jordan Gulf Bank	0.46	0.68	0.73	0.63	0.54	0.64	0.63	0.88	0.85	0.38	0.37	0.54	0.87	0.62	0.63	0.17
Jordan Islamic Bank	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.81	0.55	0.80	0.85	0.93	0.13
Jordan Kuwait Bank	0.70	0.74	0.87	0.78	0.95	0.81	0.79	0.89	0.61	0.54	0.62	0.67	1.00	0.83	0.77	0.13
Kuwait National												1.00	1.00	1.00	1.00	0.00
Lebanon												1.00	1.00	0.64	0.88	0.21
National Bank	0.86	0.81	0.88	0.99	0.93	0.81	0.78	0.80	0.61	0.65	0.55	0.68	0.63	0.69	0.76	0.13
Philadelphia Bank	0.81	0.70	0.58	0.51	0.72	0.74	0.58	0.53	0.66						0.65	0.10
Societe General	0.83	0.84	0.88	0.89	0.78	0.83	0.58	0.60	0.66	0.63	0.62	0.63	0.88	0.63	0.74	0.12
Standard Chartered	0.84	0.82	0.99	1.00	0.85	0.99	0.97	0.75	0.68	1.00	0.97	0.98	0.95	0.83	0.90	0.11
Union Bank	0.85	0.86	1.00	1.00	1.00	0.73	0.73	0.75	0.62	0.73	0.78	0.88	1.00	0.83	0.84	0.12
Average per year	0.84	0.84	0.87	0.87	0.86	0.86	0.83	0.84	0.79	0.78	0.77	0.78	0.87	0.77		

Appendix 6.6 Profit Efficiency Scores for Jordanian Banks (DEA) 1993-2006

Bank Name	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Bank Average	S.D
ABC	0.56	0.71	0.44	0.56	0.76	0.52	0.45	0.75	0.67	0.69	0.69	0.72	0.67	0.66	0.63	0.11
Amman Bank	0.29	0.04	0.04												0.12	0.14
Arab Bank	0.79	1.00	1.00	1.00	0.95	0.96	0.75	0.94	0.98	0.95	0.97	0.98	0.99	0.98	0.95	0.08
Arab Egyptian Bank	0.49	0.40	0.43	0.45	0.63	0.35	0.43	0.73	0.54	1.00	0.44	0.69	1.00	1.00	0.61	0.24
Arab Investment Bank	0.56	0.51	0.49	0.53	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.64	0.69	0.65	0.79	0.22
Arabic Islamic Bank						1.00	0.73	0.64	1.00	1.00	1.00	0.95	1.00	0.76	0.90	0.14
Audi												0.30	0.28	0.43	0.33	0.08
Business Bank	0.60	0.63	1.00	0.47											0.68	0.23
Cairo Amman Bank	0.35	1.00	1.00	0.43	0.56	0.41	0.37	0.58	0.53	0.45	0.52	0.61	0.73	0.60	0.58	0.21
City Bank	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00
Export Bank						1.00	1.00	1.00	1.00	1.00	1.00	0.96	1.00	1.00	1.00	0.01
Housing Bank	1.00	0.88	0.63	0.61	0.94	0.95	0.70	0.95	0.99	0.96	0.95	0.97	0.99	1.00	0.89	0.14
HSBC	0.73	0.74	0.60	0.60	0.76	0.44	0.35	0.73	0.63	0.83	0.57	0.53	0.56	0.55	0.62	0.13
Jordan Bank	0.48	0.26	0.37	0.37	0.40	0.33	0.36	0.46	0.43	0.60	0.42	0.45	0.53	0.63	0.44	0.10
Jordan Bank for Investment and Finance	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00
Jordan Gulf Bank	0.01	0.25	0.35	0.29	0.31	0.13	0.39	0.71	0.93	0.11	0.10	0.32	0.64	0.54	0.36	0.26
Jordan Islamic Bank	0.72	0.95	0.82	0.82	0.90	0.32	0.40	0.62	0.70	0.48	0.81	0.38	0.54	0.53	0.64	0.20
Jordan Kuwait Bank	0.41	0.63	0.38	0.49	0.84	0.62	0.52	0.84	0.72	0.91	0.76	0.93	1.00	1.00	0.72	0.21
Kuwait National												1.00	1.00	1.00	1.00	0.00
Lebanon												1.00	1.00	0.92	0.97	0.04
National Bank	0.59	0.61	0.53	0.63	0.59	0.68	0.03	0.67	0.67	0.16	0.04	0.31	0.56	0.50	0.47	0.23
Philadelphia Bank	1.00	1.00	1.00	1.00	1.00	0.14	0.64	0.58	0.67						0.78	0.30
Societe General	1.00	1.00	1.00	1.00	1.00	0.56	1.00	1.00	1.00	1.00	1.00	0.69	1.00	1.00	0.95	0.14
Standard Chartered	0.60	1.00	1.00	0.80	0.83	0.68	0.53	0.76	0.64	1.00	0.82	0.84	1.00	0.92	0.82	0.16
Union Bank	0.58	0.43	1.00	1.00	1.00	0.22	0.47	0.73	0.62	0.68	0.54	0.95	1.00	1.00	0.73	0.26
Average per year	0.64	0.70	0.70	0.69	0.80	0.61	0.61	0.78	0.79	0.78	0.72	0.74	0.83	0.80		

Appendix 6.7 New Profit Efficiency Scores for Jordanian Banks (DEA) 1993-2006

Bank Name	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Bank Average	S.D
ABC	0.58	0.69	1.00	0.75	0.72	0.44	0.43	0.71	0.66	0.69	0.83	1.00	1.00	0.65	0.73	0.18
Amman Bank	0.29	0.05	0.04												0.13	0.14
Arab Bank	0.76	0.97	1.00	1.00	1.00	1.00	1.00	0.95	1.00	0.95	0.94	0.96	0.95	0.98	0.96	0.06
Arab Egyptian Bank	0.53	0.54	0.50	0.66	1.00	0.37	0.41	0.66	0.22	1.00	1.00	0.24	0.28	0.06	0.53	0.30
Arab Investment Bank	1.00	0.73	0.64	0.81	0.66	1.00	0.88	0.65	0.57	1.00	1.00	0.51	0.42	0.43	0.74	0.22
Arabic Islamic Bank						1.00	1.00	1.00	1.00	1.00	1.00	0.47	1.00	1.00	0.94	0.18
Audi												0.26	0.20	0.29	0.25	0.05
Business Bank	1.00	1.00	0.61	0.24											0.71	0.36
Cairo Amman Bank	0.27	0.30	0.45	0.62	0.68	0.36	0.38	0.61	0.45	0.45	0.66	0.77	1.00	1.00	0.57	0.24
City Bank	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00
Export Bank						1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.98	1.00	0.01
Housing Bank	1.00	0.85	1.00	0.90	1.00	1.00	0.71	0.95	0.98	0.96	0.96	0.97	0.98	1.00	0.95	0.08
HSBC	1.00	0.95	0.89	0.95	0.89	0.41	0.31	0.88	1.00	0.83	1.00	0.93	1.00	1.00	0.86	0.22
Jordan Bank	1.00	0.31	0.43	0.67	0.52	0.32	0.39	0.82	1.00	0.60	0.57	0.55	0.89	0.72	0.63	0.23
Jordan Bank for Investment and Finance	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00
Jordan Gulf Bank	0.01	0.24	0.40	0.39	0.31	0.11	0.33	0.63	0.60	0.11	0.20	0.40	1.00	0.49	0.37	0.26
Jordan Islamic Bank	0.58	1.00	0.72	0.89	0.85	0.69	0.42	0.75	0.98	0.48	0.37	0.21	0.92	0.49	0.67	0.25
Jordan Kuwait Bank	0.43	0.54	0.40	0.69	0.70	0.50	0.51	0.90	0.76	0.91	0.99	0.98	1.00	1.00	0.74	0.23
Kuwait National												1.00	1.00	1.00	1.00	0.00
Lebanon												1.00	0.81	0.43	0.75	0.29
National Bank	1.00	1.00	1.00	0.88	0.70	0.30	0.02	0.66	0.81	0.16	0.03	0.24	1.00	0.53	0.60	0.38
Philadelphia Bank	1.00	1.00	0.74	0.56	0.64	0.08	0.57	0.54	0.67						0.65	0.27
Societe General	1.00	1.00	1.00	1.00	1.00	0.65	0.56	1.00	1.00	1.00	1.00	0.63	1.00	0.70	0.90	0.17
Standard Charter	0.62	0.83	0.69	1.00	0.95	0.57	0.45	0.83	1.00	1.00	1.00	1.00	1.00	1.00	0.85	0.19
Union Bank	0.60	0.44	1.00	0.30	0.02	0.23	1.00	0.61	0.45	0.68	1.00	1.00	1.00	1.00	0.67	0.34
Average per year	0.73	0.72	0.72	0.75	0.76	0.60	0.62	0.81	0.81	0.78	0.82	0.73	0.88	0.76		